ANNUAL REPORT

UPON THE

IMPROVEMENT OF THE NAVIGATION OF RED RIVER, LOUISIANA, AND OF CERTAIN RIVERS IN LOUISIANA, TEXAS, MISSISSIPPI, ARKANSAS, AND TENNESSEE; AND WATER-GAUGES ON THE MISSISSIPPI AND ITS PRINCIPAL TRIBUTARIES.

IN CHARGE OF

J. H. WILLARD,

CAPTAIN, CORPS OF ENGINEERS, U. S. A.;

BEING

APPENDIX W

OF THE

ANNUAL REPORT OF THE CHIEF OF ENGINEERS FOR 1890.

WASHINGTON:
GOVERNMENT PRINTING OFFICE.
1890.

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[EXTRACT FROM THE ANNUAL REPORT OF THE CHIEF OF ENGINEERS TO THE SECRETARY OF WAR.]

OFFICE OF THE CHIEF OF ENGINEERS,
UNITED STATES ARMY,
Washington, D. C., October 4, 1890.

* * * * * * *

WESTERN RIVERS.

IMPROVEMENT OF RED RIVER, AND OF CERTAIN RIVERS IN THE STATE OF ARKANSAS, AND OF CERTAIN RIVERS IN THE STATES OF LOUISIANA, MISSISSIPPI, AND TENNESSEE, TRIBUTARY TO THE MISSISSIPPI—WATER-GAUGES ON THE MISSISSIPPI AND ITS PRINCIPAL TRIBUTARIES.

Officer in charge, Capt. J. H. Willard, Corps of Engineers; Division Engineer, Col. C. B. Comstock, Corps of Engineers.

1. *Red River, Louisiana and Arkansas.*—This improvement was begun in 1828, and appropriations aggregating $535,765.50 were made between 1828 and 1852. Between 1841 and 1852 no appropriation was made, and a longer interval elapsed between 1852 and 1872, during which the results of former work were lost.

The present improvement, from Fulton, Ark., to the Atchafalaya, commenced in 1872, at which time navigation above Shreveport, La., was almost impossible on account of the great raft; the falls at Alexandria were impassable at low water; navigation during low stages between Shreveport and Grand Ecore, La., was affected seriously by the gradual enlargement of Tone's Bayou Outlet, which depleted the main channel of the river below; and the entire river was much obstructed by snags, sunken logs, wrecks, leaning trees, etc.

The project contemplated the removal of raft, snags, wrecks, and other obstructions; closing Tone's Bayou Outlet; opening a channel through the falls at Alexandria; and deepening the channel at shoal places. Also protection of caving banks at Alexandria. Owing to the nature of the work, it must be continuous, and no estimate of cost was made on this account.

The amount expended to June 30, 1889, was $839,232.92. The great raft was opened in 1873, and operations since have prevented its forming again and secured an enlarged channel with greater depth everywhere. The channel excavation and dam at the Falls of Alexandria were completed in 1885, and a dam and training-wall for protecting the caving bank were built the same year. The removal of snags and clearing the banks for general improvement of the river were not begun until 1878, but since 1885 operations have been confined to this class of work. The act of August 11, 1888, provided for continuing work in Cypress Bayou and in Bayou Dorcheat (tributaries of Red River) by allotments of $5,000 for each from the appropriation for Red River, and work in both streams was resumed in 1889.

In the past year three snag boats and a dredge continued the work of removing obstructions whenever the stage of water would permit, and the snag-boats patrolled the river keeping drift in motion and preventing formation of raft during high water.

A small snag-boat and a dredge were employed on the Cypress Bayou route from December 31 to March 8 in removing obstructions and widening and deepening the cuts. The balance available for this work June 30 was only $325.82.

Work in Bayou Dorcheat, etc., was continued from July 1 to October 9, when it was completed. This consisted of going over the work done in 1884, cutting the brush which had grown since and removing dangerous stumps, leaning timber, etc. Nothing further is required for this stream.

Field work of the survey from Fulton to the Atchafalaya was continued down-stream to Grand Bend, La., near Alexandria, and 406 miles below Fulton, and suspended the middle of February, after which a small force was retained in the office to work up the notes. To complete the project, about 100 miles of the lower river have to be surveyed, a part of the lines revised between Shreveport and Caspiana, La., and connections made with the survey of Bayou Pierre, and secondary triangulation from the mouth of Atchafalaya back to Fulton. The balance available for this work June 30 was $111.60.

The amounts expended during the past year were:

For general improvement (including liabilities $15.14)	$23,751.56
For Cypress Bayou, etc. (including liabilities $1.07)	2,918.73
For Bayou Dorcheat	1,999.16
For survey (including liabilities $3.81)	20,881.32
Total	49,550.77

Red River frequently is jammed in a few hours with acres of drift, and raft formation is prevented only by prompt service of snag-boats. Should jams occur when funds are exhausted, and none expected for some time, it is probable that new rafts would form, diverting the river from the bed on which thousands of dollars have been spent, to lose itself in the low lands and bayous, destroying by the way a fertile country that has been reclaimed from overflow by the improvement and the construction of levees by the State of Louisiana.

July 1, 1889, amount available		$62,767.08
July 1, 1890, amount expended during fiscal year, exclusive of liabilities outstanding July 1, 1889	$49,530.75	
July 1, 1890, outstanding liabilities	20.02	
		49,550.77
July 1, 1890, balance available		13,216.31
Amount appropriated by act of September 19, 1890		100,000.00
Amount available for fiscal year ending June 30, 1891		113,216.31

(See Appendix W 1.)

2. *Ouachita and Black Rivers, Arkansas and Louisiana.*—The improvement of Ouachita River commenced in 1871. Black River, the connecting stream between Ouachita and Red Rivers, was added under the same head of appropriation by the act of 1884. The original project contemplated improvement by a system of locks and dams, but was abandoned in 1874 on account of its cost and doubtful utility. The present project contemplates removing snags, logs, wrecks, leaning timber, etc., obstructing navigation, and the improvement of shoal places between Camden, Ark., and the mouth of Black River, 341 miles. No

estimate of cost is given, as the nature of the work requires that it be continuous.

The total amount expended to June 30, 1889, was $311,665.03, of which $198,077.16 were applied to operations under the present project. This work consisted principally of removing logs and snags from the channel and cutting leaning timber. Stone and brush wing dams were built at some of the shoals, increasing the channel depth from 1 to over 3 feet.

In the past fiscal year a large snag-boat was employed from August 17 until September 20, thoroughly removing all snags, etc., obstructing the channel between Taylor's Bar, 25 miles below Monroe, La., and the mouth of Black River. A chopping party commenced work at Camden December 20 and continued down stream 12 miles until January 6, when a rise stopped operations. Nothing has been done since, on account of continued high water.

Since the project for improvement by locks and dams was abandoned, three examinations have been made with a view to slack-water navigation, the last in 1889, and the reports on all agree that work should continue under the adopted project for the present.

July 1, 1889, amount available		$15,384.97
July 1, 1890, amount expended during fiscal year, exclusive of liabilities outstanding July 1, 1889	$8,660.08	
July 1, 1890, outstanding liabilities	2.89	
		8,662.97
July 1, 1890, balance available		7,172.00
Amount appropriated by act of September 19, 1890		15,000.00
Amount available for fiscal year ending June 30, 1891		22,172.00

(See Appendix W 2).

3. *Ouachita River, Arkansas, above Camden.*—The project for this improvement, based on an examination made in 1887, contemplated removing snags, cutting leaning timber, and building brush-dams at the shoals between Camden and Arkadelphia, Ark., at an estimated cost of $9,000.

The act of August 11, 1888, appropriated $9,000 to complete the work.

A chopping party commenced operations at Arkadelphia, September 25, 1889, and continued down stream to Camden, which was reached December 19. This work put the river in fair condition for navigation above Camden to Arkadelphia, at stages permitting boats to run to the former place. There is no commerce at present, but a small boat is building at Arkadelphia to run in this trade.

The available balance will be expended next low-water season in going over the work and completing the project.

July 1, 1889, amount available	$9,000.00
July 1, 1890, amount expended during fiscal year	6,599.26
July 1, 1890, balance available	2,400.74

(See Appendix W 3.)

4. *Bayou D'Arbonne, Louisiana.*—The project for this improvement was adopted in 1884, and contemplates the removal of snags, logs, wrecks, leaning trees, etc., obstructing navigation from Stein's Bluff, on the Corney Branch, to the mouth of D'Arbonne, 42½ miles, at an estimated cost of $15,000.

The amount expended to June 30, 1889, was $8,000. The removal of obstructions increased the period of navigation about one month.

In the past year work was continued from July 1 to August 2, when the funds were exhausted. The work has enabled boats of double the capacity of those used formerly to navigate the stream during high water, and freight rates have been reduced fully one-half.

The work is not permanent, as new obstructions are forming continually.

July 1, 1889, amount available	$1,000.00
July 1, 1890, amount expended during fiscal year, exclusive of liabilities outstanding July 1, 1889	1,000.00
Amount appropriated by act of September 19, 1890	2,000.00
Amount (estimated) required for completion of existing project. Submitted in compliance with requirements of sections 2 of river and harbor acts of 1866 and 1867.	4,000.00

(See Appendix W 4.)

5. *Little River, Louisiana.*—The project for this work was based upon an examination made in 1887, and contemplated removing sunken logs and cutting the most obstructive leaning timber between Catahoula Lake and Trinity, La., at a cost of $2,500.

The act of August 11, 1888, appropriated $2,500 for this purpose.

The sum of $1,708.27 was expended in the fiscal year 1889, and the balance during the past fiscal year.

The work contemplated by the project having been completed, no further estimate is made.

July 1, 1889, amount available	$791.73
July 1 1890, amount expended during fiscal year, exclusive of liabilities outstanding July 1, 1889	791.73

(See Appendix W 5.)

6. *Bayou Bartholomew, Louisiana and Arkansas.*—This improvement was begun in 1881, the project contemplating the removal of snags, logs, wrecks, leaning timber, etc., obstructing navigation between Baxter, Ark., and the mouth, a distance estimated to be 213 miles.

The amount expended to June 30, 1889, was $23,000. Work had extended over nearly the entire portion of the bayou included in the project, and lessened the dangers of navigation greatly.

In the past fiscal year a chopping party and light snag-boat commenced removing obstructions early in August, and continued until the available balance was expended.

Before the improvement commenced three months was the average duration of the navigable season. Now boats of double the capacity are employed for six months of the year, make trips in one-half the time formerly required, and have reduced freight rates 50 per cent.

Permanent improvement can not be secured, as obstructions are forming continually.

July 1, 1889, amount available		$5,000.00
July 1, 1890, amount expended during fiscal year, exclusive of liabilities outstanding July 1, 1889	$4,995.10	
July 1, 1890, outstanding liabilities	.34	
		4,995.44
July 1, 1890, balance available		4.56
Amount appropriated by act of September 19, 1890		5,000.00
Amount available for fiscal year ending June 30, 1891		5,004.56

(See Appendix W 6.)

7. *Bayou Bœuf, Louisiana.*—The project for improving this bayou was adopted in 1881, and contemplated removing snags, logs, leaning timber, etc., obstructing navigation between Wallace's Landing and the mouth, about 280 miles. Three outlets of the bayou near Point Jefferson, La., were examined in 1884 and their closure recommended at an estimated cost of $8,500.

The amount expended to June 30, 1889, was $25,022.48. The removal of obstructions lessened the danger of navigation and enabled boats to run to Point Jefferson, 19 miles below Wallace's, at high stages. In 1888 and 1889 the outlets were closed as follows: Outlet No. 1 was closed substantially, the second by a heavy dam at a lower elevation, and the third by a low dam, this being all that could be done with small appropriations.

In the past fiscal year three week's work in December was done by a light snag-boat, thoroughly clearing the obstructions from the 60 miles above the mouth. This exhausted the small balance of the appropriation.

During the overflow from the Mississippi River last spring the dams closing the outlets were destroyed. It is essential that they be restored at once, as the water ultimately will leave the main channel if the outlets remain open, and navigation of the bayou will be destroyed.

July 1, 1889, amount available		$977.52
July 1, 1890, amount expended during fiscal year, exclusive of liabilities outstanding July 1, 1889	$955.43	
July 1, 1890, outstanding liabilities	22.00	
		977.43
July 1, 1890, balance available		.09
Amount appropriated by act of September 19, 1890		5,000.00
Amount available for fiscal year ending June 30, 1891		5,000.09

(See Appendix W 7.)

8. *Tensas River and Bayou Maçon, Louisiana.*—The project for improving Tensas River was adopted in 1881, and contemplated removing snags, logs, and leaning timber obstructing navigation between Dallas and its mouth, about 180 miles, at an estimated cost of $23,000. Bayou Maçon, a tributary, was added under the same head of appropriation by act of 1884, and the project contemplates removing the same class of obstructions between Floyd and its mouth, about 130 miles, at an estimated cost of $17,000.

The amount expended to June 30, 1889, was $15,768.99; $7,425 of which had been applied to improving Tensas River, and $8,343.99 to Bayou Maçon. The obstructions were removed as far as practicable with these amounts, but as new obstructions are forming continually permanent results were not attained.

No work was done in the past fiscal year, the balance available being too small.

July 1, 1889, amount available	$231.01
July 1, 1890, amount expended during fiscal year, exclusive of liabilities outstanding July 1, 1889	104.25
July 1, 1890, balance available	126.76
Amount appropriated by act of September 19, 1890	5,000.00
Amount available for fiscal year ending June 30, 1891	5,126.76
Amount (estimated) required for completion of existing project	19,000.00

Submitted in compliance with requirements of sections 2 of river and harbor acts of 1866 and 1867.

(See Appendix W 8.)

9. *Big Black River, Mississippi.*—The project for this improvement contemplated removing snags, logs, wrecks, and leaning trees obstructing navigation between the mouth and Cox's Ferry, 130 miles above, at an estimated cost of $32,000. Such improvement can not be permanent, as new obstructions are added from time to time.

The first appropriation for this work, by act of 1884, was applied to removing obstructions in the 75 miles above the mouth. No work has been done since.

The appropriation by act of 1886 contained the following proviso: "No part of this appropriation shall be used until the State of Mississippi shall have first caused the bridges south of the Vicksburg and Meridian Railroad to be so constructed as not to obstruct the navigation of said stream." This requirement has not been complied with, one bridge yet obstructing navigation, located about 25 miles below the railroad crossing referred to in the act.

July 1, 1889, amount available	$5,000
July 1, 1890, balance available	5,000
Amount (estimated) required for completion of existing project. Submitted in compliance with requirements of sections 2 of river and harbor acts of 1866 and 1867.	22,000

(See Appendix W 9.)

10. *Yazoo River, Mississippi.*—Work in this river was begun in 1873 The project contemplates removal of snags, logs, wrecks, and leaning timber obstructing navigation throughout the entire length of the stream. New obstructions are brought into the river every year by floods, sliding banks, etc., and no estimates for permanent improvement have been made on this account.

The amount expended to June 30, 1889, was $177,557.74. Prior to improvement the river was obstructed by a large number of wrecks, and by snags and leaning timber. Nine of the steam-boats sunk during the war were removed by contract in 1873–'74, and snag-boats have operated in the river since whenever funds were available, keeping it in navigable condition from its head to its mouth the year round.

In the past fiscal year a large snag-boat was employed on this work from October 3 to November 8, benefiting low-water navigation greatly. A pumping dredge-boat, authorized by act of August 11, 1888, was purchased.

The shifting bar at the mouth of the river is the most serious obstruction to navigation. Boats that could navigate the principal streams of the Yazoo Valley system (about 900 miles) without hindrance, are prevented from entering or leaving without lightening and at times navigation across the bar is stopped altogether.

July 1, 1889, amount available		$12,442.26
July 1, 1890, amount expended during fiscal year, exclusive of liabilities outstanding July 1, 1889	$9,317.39	
July 1, 1890, outstanding liabilities	.34	
		9,317.73
July 1, 1890, balance available		3,124.53
Amount appropriated by act of September 19, 1890		25,000.00
Amount available for fiscal year ending June 30, 1891		28,124.53

(See Appendix W 10.)

11. *Tchula Lake, Mississippi.*—The project for this improvement was adopted in 1881, and contemplates removing snags, logs, leaning timber,

etc., obstructing navigation, to permit light-draught steam-boats to enter the lake earlier in the season.

The amount expended to June 30, 1890, was $10,278.57.

No work was done during the past fiscal year.

The work is of such nature that it must be gone over from time to time to remove obstructions that are forming continually.

July 1, 1889, amount available	$1,721.43
July 1, 1890, balance available	1,721.43
Amount appropriated by act of September 19, 1890	3,000.00
Amount available for fiscal year ending June 30, 1891	4,721.43

(See Appendix W 11.)

12. *Tallahatchee River, Mississippi.*—This improvement was begun in 1879. The project contemplated removing snags, sunken logs, and leaning timber obstructing low-water navigation below mouth of Coldwater, a distance of 165 miles, and a wreck in the channel 8 miles above the mouth. The estimated cost of such improvement was $40,000, if completed in two seasons.

The amount expended to June 30, 1889, was $29,548.11, of which $10,000 were expended above mouth of Coldwater (a part of the river not included in the project), as required by the terms of the appropriations. The remainder was expended between the mouth of Tallahatchee and Sharkey's Landing, 100 miles above. Before work commenced the river was navigable about six months of the year. Now boats run to Sharkey's the year round.

In the past fiscal year a large snag-boat was employed from November 8 to December 24, when the funds were exhausted.

A snag-boat should be used for a short time each year to remove heavy obstructions from this river.

July 1, 1889, amount available	$2,951.89
July 1, 1890, amount expended during fiscal year, exclusive of liabilities outstanding July 1, 1889	2,951.89
Amount appropriated by act of September 19, 1890	5,000.00
Amount (estimated) required for completion of existing project. Submitted in compliance with requirements of sections 2 of river and harbor acts of 1866 and 1867.	12,500.00

(See Appendix W 12.)

13. *Steele's Bayou, Mississippi.*—Work in this bayou commenced in 1884. The project contemplates removing snags, stumps, leaning timber, etc., obstructing navigation during high water.

The amount expended to June 30, 1889, for this purpose, was $6,829.35.

A light-draught steam-boat was employed from July 12 to 17, 1889, in removing obstructions from the lower part of the bayou.

July 1, 1889, amount available	$670.65
July 1, 1890, amount expended during fiscal year, exclusive of liabilities outstanding July 1, 1889	670.65
Amount appropriated by act of September 19, 1890	2,500.00

(See Appendix W 13.)

14. *Big Sunflower River, Mississippi.*—Work in this river commenced in 1879. The project contemplated building wing-dams to scour a channel from 3 feet to 40 inches deep at the bars, and the removal of snags,

sunken logs, and leaning timber obstructing navigation, at an estimated cost of $66,000.

The amount expended to June 30, 1889, was $50,243.73.

Operations extended over the navigable portion of the river, from Clarksdale to its mouth; an increased depth of channel of from 18 inches to 3½ feet was gained at the bars where dams were built, and a large number of obstructions were removed. The improvement is not permanent, as new obstructions are added every year.

In the past fiscal year the removal of obstructions and construction of dams were continued for sixteen days with a small steam-boat hired for the purpose.

Before the improvement commenced the river was navigable for light boats about six months each year, and it was an unusual thing for a boat to make a trip under eight days. Now the river is navigable the year round, but with difficulty about three months of the time, and boats make the trip in five days. Insurance rates have been reduced about one-fifth, and freight rates more than one-half. The country along the river is filling up rapidly with settlers, which is attributable in part to the improvement of navigation.

July 1, 1889, amount available	$1,756.27
July 1, 1890, amount expended during fiscal year, exclusive of liabilities outstanding July 1, 1889	1,756.27
Amount appropriated by act of September 19, 1890	5,000.00
Amount (estimated) required for completion of existing project. Submitted in compliance with requirements of sections 2 of river and harbor acts of 1866 and 1867.	9,000.00

(See Appendix W 14.)

15. *Big Hatchee River, Tennessee.*—This improvement was begun in 1880. The project contemplates removing logs, snags, leaning timber, etc., obstructing navigation from Bolivar, Tenn., to the mouth, about 240 miles, to render the river navigable for light-draught boats throughout the year. The improvement will not be permanent, as new obstructions are added from time to time.

Before work commenced navigation was virtually suspended by reason of the obstructions. The amount expended to June 30, 1889, was $23,989.02, rendering the river navigable about seven months of the year.

In the past fiscal year operations were continued with a small hand-propelled snag-boat, from August 19 to October 31, and effective work was done in the way of removing sunken logs from the channel below Rialto, 57 miles from the mouth.

July 1, 1889, amount available		$3,010.98
July 1, 1890, amount expended during fiscal year, exclusive of liabilities outstanding July 1, 1889	$3,010.17	
July 1, 1890, outstanding liabilities	.38	
		3,010.55
July 1, 1890, balance available		.43
Amount appropriated by act of September 19, 1890		5,000.00
Amount available for fiscal year ending June 30, 1891		5,000.43

(See Appendix W 15.)

16. *Forked Deer River, Tennessee.*—Work in South Fork of this river commenced in 1883. The act of August 11, 1888, added North Fork and main river under the general head of improving Forked Deer River.

The project contemplates removing snags, logs, leaning timber, etc., from South Fork below Jackson, North Fork below Dyersburgh, and the main river.

The amount expended to June 30, 1889, was $17,979.21, of which $12,500 were applied to South Fork, $3,862.85 to North Fork, and $1,616.36 to the main stream. The two forks were put in fairly good navigable condition, but in the main stream no material benefit was gained.

In the past fiscal year work was continued in the main river and North Fork until the balances of the last appropriation were expended, viz: Main river, $883.64; North Fork, $637.15.

South Fork is obstructed by numerous bridges which render steamboat navigation impracticable, and for the present further improvement is not deemed necessary. The project for North Fork is completed.

July 1, 1889, amount available	$1,520.79
July 1, 1890, amount expended during fiscal year, exclusive of liabilities outstanding July 1, 1889	1,520.79
Amount appropriated by act of September 19, 1890	2,500.00

(See Appendix W 16.)

17. *Water-gauges on the Mississippi River and its principal tributaries.*—These gauges were established in 1871 under joint resolution of Congress, approved February 21, 1871 (section 5252, Revised Statutes), for the purpose of securing information from continuous records, with a view to protecting the alluvial basin of the Mississippi against overflow, improving navigation, and giving reliable reports for the benefit of river-men and planters.

The amount expended to June 30, 1889, was $74,233.71. Nineteen gauges were established originally, and an additional one at Nashville, Tenn., in 1873. Observations commenced at each station as soon as the gauge was set up, and with a few exceptions have continued regularly since. The gauge at Rock Island, Ill., was abandoned in 1879. In 1881 bulletins were erected at stations on the Mississippi for the purpose of giving passing boats the gauge readings. Since February 1, 1887, the gauges have been read twice a day; formerly they were read only once.

Owing to small and irregular appropriations, caused by frequent failures of appropriations for rivers and harbors, many difficulties were encountered in making this work continuous, until the passage of the act of August 11, 1888, section 6 of which provided a permanent, indefinite, appropriation for securing uninterrupted gauging.

In the past year observations, inspections, and repairs were continued. Larger bulletins were set up on the Mississippi, and the old bulletins repaired for use at stations on the tributaries, which heretofore have not been provided with them. New gauges were established at Fulton and Garland, Ark., and Shreveport, La., on Red River, and at Donaldsonville, La., on the Mississippi. The gauge at Fort Leavenworth, Kans., was abandoned, but will be maintained by the Missouri River Commission. Efforts are being made to find the benches of the Mississippi Delta Survey, and thus connect observations of early years with those since 1871, and also to connect the gauges with the same datum plane.

Additional gauges are needed at various places on the principal tributaries, and requests are made from time to time for new gauges and bulletins by persons interested in navigation.

July 1, 1889, amount available, (provided by act of August 11, 1888.)		$9,600.00
July 1, 1890, amount expended during fiscal year	$7,718.34	
July 1, 1890, amount allotted for gangings at St. Paul	600.00	
July 1, 1890, outstanding liabilities	5.19	
		8,323.53
July 1, 1890, balance unexpended		1,276.47

(See Appendix W. 17.)

To comply with a resolution of the House of Representatives of February 6, 1890, the local engineer, Captain Willard, was directed to make a special report respecting the improvement of *Cypress Bayou and the lakes between Jefferson, Tex., and Shreveport, La.* This report was transmitted to Congress, and published as House Ex. Doc. 252, Fifty-first Congress, first session. (See also Appendix W 18.)

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[To be inserted at page 1819, vol. 3, Annual Report, Chief of Engineers, 1890.]

ERRATA IN REPORT OF CAPT. J. H. WILLARD, CORPS OF ENGINEERS, FOR FISCAL YEAR ENDING JUNE 30, 1890, APPENDIX W, ANNUAL REPORT, CHIEF OF ENGINEERS, 1890.

Page 1821.—Line 2 under general improvement, change Constatta to Conshatta.
Page 1824.—Line 7 under Alexandria Harbor, change of to or.
Page 1824.—Lines 20–28 under Alexandria Harbor put balance of paragraph after "Captain Bergland said" in quotations.
Page 1825.—Line 28, change of Alexandria to at Alexandria.
Page 1826.—Line 19 under Cypress Bayou, change 21st to 31st.
Page 1828.—Between sixth and seventh lines from bottom of page insert a dash, to separate report upon Bayou Dorcheat from succeeding remarks on that page and page 1829.
Page 1830.—Line 32, change plant to plan.
Page 1831.—Line 28, change comma after 100 to decimal sign, and × before 0.018 to ±.
Page 1831.—Line 32, change base to bases.
Page 1831.—Line 34, change Liver to River.
Page 1831.—Line 36, change sections to section, and length to lengths.
Page 1831.—Line 47, change table to tables.
Page 1831.—Line 51, change generally to general.
Page 1831.—Line 55, next to last, change result to results.
Page 1834.—Line 43, between floods and etc. insert and sickness.
Page 1835.—Line 8, strike out there.
Page 1835.—First line of Money statement, change $21,111.00 to $21,111.72.
Page 1836.—Line 13, strike out part.
Page 1838.—Last line, change measurement to measurements.
Page 1841.—Line 16, in denominator, change $-t_n$ to $+t_n$.
Page 1841.—Line 18, in denominator, change $2e$ to $2l$, and se^3 to $8l^3$.
Page 1841.—Line 19, change e to l.
Page 1841.—Lines 22, 24, 28, and 29, change $2e$ to $2l$, and se^3 to $8l^3$.
Page 1842.—First Mean Reading in table foot of page, change 19.1 to 19.4, and under Remarks change C. L. to C. H.
Page 1843.—Line 2, change Themometer to Thermometer.
Page 1843.—Heading of last two colums of table, change Erase correction to Grade correction.
Page 1843.—Heading of fourth and fifth columns of table under Steel tape, change $S + S^*$ to $S + S'$.
Page 1843.—Line 11 of column T − 60°, change −1.0 to −0.1.
Page 1843.—Line 16 of column S', change + 0.0209 to + 0.0207.
Page 1843.—Line 19 of column Σh^2, change 0.0937 to 0.0037.
Page 1843.—Line 21 of column Σh^2, change 0.0037 to 0.0032.
Page 1843.—Line 26 of column Σh^2, change 0.0043 to 0.0049.
Page 1843.—Line 20 of column No. 1522, change 56.9 to 59.9.
Page 1843.—Line 21 of column No. 791, change 59.5 to 58.5.
Page 1843.—Line 1 under table, change cape to tape.
Page 1843.—First equation, last denominator above line, change 3144.56 to 8144.56.
Page 1844.—Strike out + sign at head of eighth column of table, and insert + before the readings on lines 1–7 below.
Page 1844.—Lines 2 and 3, fourth column of table, change 0.0848 to 0.0048.
Page 1845.—Line 8, change 114.°7 to 114.7°.
Page 1845.—Fourth column of table, line 8, change + 3.2 to −3.2.
Page 1847.—Line 4, change Caspiæa to Caspiana.
Page 1847.—Line 7, change 0 05 to 0.05, by inserting decimal sign.
Page 1847.—Line 15 from bottom, change 9 hours to 0 hours.
Page 1848.—Line 2 above *Detailed estimates*, change qualities to quantities.
Page 1848.—Insert a dash above *Detailed estimates*, to separate same from report on Survey of Red River.
Page 1849.—Correct spelling of Administration in heading Admidistration and Inspection.
Page 1851.—Insert a dash above table 1, to separate same from Commercial Statistics.
Page 1852.—Second column, line 44, change 981.8 to 681.8.
Page 1852.—Second column, next to last line, change to 882.4.
Page 1852.—Third column, line 15, change 279° 23′ to 293° 22′.
Page 1852.—Fourth column, item 7, change 52.12 to 52.02.
Page 1852.—Fourth column, item 11, change 42.09 to 52.09.
Page 1854.—Third column, line 1, change 76° to 71°.
Page 1854.—Fourth column, item 12 from bottom, change 43.72 to 43.73.
Page 1855.—Third column, line 45, change 822° to 322°.

Page 1857.—First column, line 33, change 269–270 to 269–271.
Page 1857.—First column, line 35, change 270–271 to 270–272.
Page 1857.—Second column, line 40, change 1577.7 to 1579.7.
Page 1857.—Second column, line 46, change 1241.1 to 1244.1.
Page 1858.—Second column, last line, change 603.8 to 609.8.
Page 1859.—Table foot of page, first column, line 3, change C. B. M. to T. B. M
Page 1859.—Table foot of page, fourth column, item 9, change +9.7388 to +0.7388.
Page 1860.—First column of table, change C. B. M. to T. B. M.
Page 1860.—Second column, opposite Bench 78, change 1.7 to 1.8.
Page 1860.—Fourth column, opposite Bench 77, change —7.2878 to —8.2878.
Page 1860.—Fifth column, opposite Bench 28, change +1.7771 to +1.7571.
Page 1860.—Fifth column, opposite Bench 62, change +14.9797 to +14.1797.
Page 1860.—Fifth column, opposite Bench 82, change —6.3449 to —6.3479.
Page 1861.—First column, change C. B. M. to T. B. M.
Page 1861.—Second column, opposite Bench 95, insert decimal sign between 1 and 6.
Page 1861.—Fourth column, opposite Bench 99, should be +8.8277.
Page 1861.—Fourth column, opposite Bench 124, change —1.3361 to —1.8361.
Page 1862.—Third column, opposite Bench 45, change 152.6 to 157.6.
Page 1863.—Last item in first column of table, change 96 to 76.
Page 1865.—Last line of description P. B. M. 34, change glazed to blazed.
Page 1865.—P. B. M. 44, change Bodeau to Bodcau, and insert, Bossier, so as to read Bodcau, Bossier Parish, La.
Page 1865.—P. B. M. 45, fifth word from end of line 1, change west to east.
Page 1865.—P. B. M. 46, change elevation from 64.433 to 65.845.
Page 1867.—P. B. M. 70, insert decimal sign so that elevation will read 35.001.
Page 1867.—B. M. 5, change elevation from 74.23 to 74.69.
Page 1867.—B. M. 6, change Brooker's to Booker's and hand to bend.
Page 1868.—B. M. 14, between the words on and lines insert section.
Page 1869.—P. R. P. 2, last line, first word, change en to on.
Page 1869.—P. R. P. 5, third line, before box-elder insert 1-foot.
Page 1869.—P. R. P. 6, change Gopp's to Topp's.
Page 1869.—P. R. P. 7, reference No. 1, change 102° to 120°.
Page 1869.—P. R. P. 10, strike out comma after Merriman.
Page 1870.—P. R. P. 25, change Poslen to Posten.
Page 1870.—P. R. P. 27, change 1¼-foot red oak to 1½.
Page 1870.—P. R. P. 31, change Colonel Vane's to Cal. Vance's.
Page 1871.—First column of table, insert Ark. after Collin's Bluff, and La. after Shreveport, Coushatta, Alexandria, and Monroe.
Page 1871.—Second column of table, item 11, change Censas to Tensas; insert La. after last six items in column.
Page 1871.—Third column of table, items 7 and 10, change Steamship to Signal Service.
Page 1874.—Next to last paragraph, correct spelling of Boeuff to Bosuf.
Page 1876.—Between third and fourth lines above Money statement, insert a dash.
Page 1876.—Strike out fifth and sixth lines of Money statement, with exception of extended amount $8,662.97.
Page 1878.—First line below summary of work done, change Walter L. Davis to Walter S. Davis.
Page 1879.—Change second amount in Money statement to $6,599.26.
Page 1879.—Line 10, under Bayou D'Arbonne, change $5,000 to $15,000.
Page 1881.—In table freights, change 1989–90 to 1889–'90.
Page 1881.—Line 11, under Little River, strike out until June.
Page 1881.—Line 14, under Little River, before 13, 1889, insert until June.
Page 1882.—In list of appropriations for Bartholomew, change date August 11, 1889, to August 11, 1888.
Page 1884.—Last amount in Money statement, change to $10,000.00.
Page 1888.—Last line, change Chapter 312 to Chapter 314.
Page 1896.—Last line above W 11, change Castor to Cassidy.
Page 1897.—First line under Tallahatchee River, change headquarters to headwaters.
Page 1903.—Line 4 from bottom, change Louisiana to Louisville.
Page 1905.—Third quantity, change 143 to 13.
Page 1911.—Third line under *April*, strike out comma between 33 and 347 and insert decimal sign.
Page 1912.—Second column of table, opposite Donaldsonville, La., change 20.72 to 19.71(?).
Page 1912.—Sixth column, last reading, change 31.00 to 34.15.
Page 1913.—In head "Itemized statement," etc., correct spelling of Requirement.
Page 1914.—Second line Money statement change $7,178.34 to $7,718.34.

APPENDIX W.

IMPROVEMENT OF RED RIVER AND OF CERTAIN RIVERS IN THE STATE OF ARKANSAS, AND OF CERTAIN RIVERS IN THE STATES OF LOUISIANA, MISSISSIPPI, AND TENNESSEE, TRIBUTARY TO THE MISSISSIPPI—WATER-GAUGES ON THE MISSISSIPPI AND ITS PRINCIPAL TRIBUTARIES.

REPORT OF CAPTAIN JOSEPH H. WILLARD, CORPS OF ENGINEERS, OFFICER IN CHARGE, FOR THE FISCAL YEAR ENDING JUNE 30, 1890, WITH OTHER DOCUMENTS RELATING TO THE WORKS.

IMPROVEMENTS.

1. Red River, Louisiana and Arkansas.
2. Ouachita and Black Rivers, Arkansas and Louisiana.
3. Ouachita River, Arkansas, above Camden.
4. Bayou d'Arbonne, Louisiana.
5. Little River, Louisiana.
6. Bayou Bartholomew, Louisiana and Arkansas.
7. Bayou Bœuf, Louisiana.
8. Tensas River and Bayou Maçon, Louisiana.
9. Big Black River, Mississippi.
10. Yazoo River, Mississippi.
11. Tchula Lake, Mississippi.
12. Tallahatchee River, Mississippi.
13. Steele's Bayou, Mississippi.
14. Big Sunflower River, Mississippi.
15. Big Hatchee River, Tennessee.
16. Forked Deer River, Tennessee.
17. Water-gauges on the Mississippi River and its principal tributaries.

SPECIAL REPORT.

18. Improvement of Cypress Bayou and the lakes between Jefferson, Tex., and Shreveport, La.

UNITED STATES ENGINEER OFFICE,
Vicksburg, Miss., July 1, 1890.

GENERAL: I have the honor to transmit herewith annual reports upon works of river improvement in my charge for the fiscal year ending June 30, 1890.

Very respectfully, your obedient servant,

J. H. WILLARD,
Captain, Corps of Engineers.

Brig. Gen. THOMAS L. CASEY,
Chief of Engineers, U. S. A.

W 1.

IMPROVEMENT OF RED RIVER, LOUISIANA AND ARKANSAS.

Red River rises in northern Texas, in the *Llano Estacado*, and flows in an easterly direction, forming the boundary between Indian Territory and Texas. At Fulton, Ark., its course changes to a general southeasterly direction, and after crossing Louisiana it enters the Mississippi at Red River Landing. The part in this district extends from Fulton, Ark., to the mouth of Atchafalaya River, about 525 miles.

The improvement by the United States was begun as early as 1828, and appropriations aggregating $535,765.50 were made at intervals between 1828 and 1852. Between 1841 and 1852 no appropriation was made, and a longer period elasped between 1852 and 1872, during which the results of former work were lost.

The present improvement began in 1872. The project contemplated the removal of raft, snags, and other obstructions; closing Tone's Bayou Outlet; opening a channel through the falls at Alexandria, La., and deepening the channel at shoal places; to improve and keep navigation open from Fulton to the mouth of Atchafalaya; also protection of caving banks at Alexandria.

The following appropriations have been made:

Act of June 10, 1872—	
For improving Tone's Bayou	$20,000
For removing raft	150,000
Act of—	
March 3, 1873, for removing raft	80,000
June 23, 1874, for removing raft	50,000
March 3, 1875, for removing raft	20,000
August 14, 1876, for removing raft and closing Tone's Bayou	35,000
Allotment of August 27, 1877, from appropriation for repair, preservation, etc., of river and harbor works, act of April 10, 1869, for closing Tone's Bayou	4,500
Act of February 7, 1878, for removing raft, etc	6,000
Act of June 18, 1878—	
For removing raft and closing Tone's Bayou	24,000
For removing snags, etc	25,000
Act of March 3, 1879—	
For removing raft and closing Tone's Bayou	15,000
For removing obstructions	22,500
For improving river above head of raft to Fulton, Ark	10,000
Act of June 14, 1880—	
For removing raft and closing Tone's Bayou	25,000
For removing obstructions	60,000
For improving river above head of raft to Fulton, Ark	10,000
Act of March 3, 1881—	
For removing raft and closing Tone's Bayou	10,000
For removing obstructions	10,000
Act of—	
August 2, 1882, for improving Red River	75,000
July 5, 1884, for improving Red River	75,000
August 5, 1886, for improving Red River, making survey of same, and completing survey of Bayou Pierre, La	75,000
Act of August 11, 1888—	
For improving Red River, Cypress Bayou, and Bayou Dorcheat	65,000
For survey of Red River	35,000
Aggregate of appropriations, 1872 to 1890	902,000

The amount expended to June 30, 1889, was $839,232.92, resulting in great benefit to navigation. A channel was opened through the great raft in 1873, and operations since, aided by the action of the current,

have secured an enlarged channel-way with greater depth everywhere, but little water being diverted from the river proper at low stages. The work of clearing obstructions and the prompt removal of jams during freshets have prevented the raft from re-forming. Several attempts were made to close Tone's Bayou, but no work has been done at this outlet since 1882, when the dam under construction was destroyed. The bayou is now filling up gradually with drift, and this, in connection with the work in the upper river, is causing "Little River" (below the mouth of the bayou to Grand Ecore), to widen and scour, the effect having been particularly noticeable the last fiscal year. The rock excavation and dam at the Falls of Alexandria were completed in 1885, and a dam and training-wall for protecting the caving bank at Alexandria were built the same year. The removal of snags and the clearing of the banks for the general improvement of the river were not begun until 1878, all former appropriations having been for removing raft and closing Tone's Bayou, but since 1885 operations have been confined to this class of work, as it was deemed advisable to defer other projects until the survey being made with a view to the permanent improvement of the river is completed. This work has diminished the risks of navigation and reduced the time of passage, freight rates, and insurance.

An annual appropriation for removing snags, etc., will be needed for many years to come, for the following reasons: In the old raft region, both above and below Shreveport, the river bed is a mass of sunken logs, which are a constant menace to low-water navigation. Some are washing loose continually and others, thoroughly water-logged, join in clumps, catch the sediment, and form bars impassable at low stages. The banks of the upper river, for hundreds of miles, are heavily timbered, and each freshet causes them to cave and slide. The quantity of obstructions thus brought into the stream is enormous, and during high water jams are of frequent occurrence in the old raft region above Shreveport, and require prompt removal before the water falls. Caving banks leave dangerous shore snags projecting far out into the river, which are a continuous trouble and should be cut after every rise and fall.

Operations of the past fiscal year were as follows:

GENERAL IMPROVEMENT.

The United States snag-boat *C. W. Howell*, M. B. Lydon, master, left Shreveport July 31 and made a trip over the river below to Coustatta, La., returning August 4 with the two survey quarter-boats. Finding the river below Shreveport too high for advantageous work, the boat, after making some repairs of hoisting machinery, etc., commenced operations in the upper river August 7, which was cleared of obstructions to Gilmer, La., 46 miles above Shreveport, August 24. By this time the river had fallen sufficiently to resume work below Shreveport and the boat returned to Coushatta August 27 and commenced working up-stream, continuing until September 20, when, on account of a sudden rise and reports of heavy jams in the old raft region, it proceeded to the upper river and was employed in removing raft, etc., between Shreveport and Kountz's Canal until September 29. On the 30th the boat returned to the lower river and continued operations between Magenta and Shreveport until October 19. The greater part of two days (October 15 and 16) was spent in towing the survey quarter-boats from Shreveport to Coushatta. From October 19 to 22 the boat was

laid up at Shreveport, undergoing necessary minor repairs; on the latter date it left for the upper river, where it was employed the remainder of the month. November was spent in the river below Shreveport. The removal of the wreck of the steamer *Falls City*, near the mouth of Loggy Bayou, was commenced November 2, but had to be abandoned November 7 on account of a rise. November 18–22 Col. C. B. Comstock, division engineer, southwest division, and I made an inspection trip on the *Howell* from Shady Grove, La., to the mouth of the river. We were accompanied by the chief State engineer of Louisiana, H. B. Richardson, who was desirous of inspecting the levees along Red River, and Assistant Engineer H. M. Marshall, of the Red River survey party. The crew was employed the first four days of December in putting the dredge *Lone Star* in working order, for the purpose of removing the towheads obstructing the channel in the old raft region near Rush Point. On the 5th the *Howell*, with the dredge in tow, left Shreveport and arrived at Rush Point the morning of the 7th. The crew was transferred to the dredge and work commenced at Towhead No. 1, the largest of those obstructions, and by the 18th it was removed, except a narrow strip through the center, the water having fallen too much for the dredge to reach this part. Dredging at the smaller towheads, Nos. 2 and 3, was finished December 23, and the boats were returned to Shreveport the following day. These towheads were accumulations of deposit on sunken raft overgrown with willows and brush, and as this part of the river is narrow they were the cause of frequent jams.

On the return to Shreveport the command of the *Howell* was transferred to J. T. Dorey, the services of Captain Lydon being needed on the work in Cypress Bayou and the lakes. After receiving supplies, etc., the *Howell* left Shreveport December 28 for the upper river, towing the hand-propelled snag-boat *Harry Breck*. The latter was left on the 31st at the upper end of Duke's Bend, Arkansas, with instructions to work down-stream. The *Howell* continued up-stream to Fulton, Ark., and was employed between that place and Garland, Ark., until January 20, removing all obstructions in sight and cutting the large trees in the bends to prevent their falling into the river. During this period the stages of water were variable, the river rising from 12 to 30 inches a day for a few days and then subsiding as rapidly, but at no time going below 10 feet. As there was no probability of low water soon the boat left Garland January 20 to return to Shreveport, removing such obstructions as appeared on the way. Information of a jam at Rush Point was received the night of January 21, and the *Howell* hastened down to remove it. The obstruction was found to extend nearly across the river, but was removed entirely January 23. The boat then continued down-stream, removing side jams, etc., and arrived at Shreveport the following day. Two days were spent at Shreveport in making necessary repairs, and the remainder of the month in patrolling the raft region to keep drift in motion and prevent jams. The boat returned to Shreveport the night of January 31, and was laid up temporarily to await a lower stage of water. On the 13th of February it left, with a minimum crew, for the purpose of patrolling the lower river to the mouth, towing the survey quarter-boats from near Alexandria to Captain Kingman's fleet at Simmesport, La., on the way down. The boat reached the mouth of the river February 19, but the water being still too high for advantageous work, it was returned to Shreveport and laid up at the fleet February 25 to await low water.

The following is a summary of the work done by the *Howell:*

Snags pulled	1,130
Stumps pulled	193
Logs removed from channel	1,075
Jams removed	7
Side jams removed	69
Shore snags removed	1,188
Leaning trees removed	4,779
Trees girdled	58
Square yards willows and brush cut	8,000
Cubic yards earth dredged at tow-heads	12,150

Wrecks removed, 1, viz., part of steamer *Falls City.*

The hand propelled snag-boat *Harry Breck*, W. W. Moore, overseer in charge, was towed to Duke's Bend, Ark., by the snag-boat *Howell*, December 31. As no work was required in that immediate vicinity, the boat was moved up-stream about 4 miles and commenced work at Terry's farm in Smith's Bend. Operations consisted chiefly in clearing caving banks, and cutting the trees into short lengths to prevent their forming obstructions. Where the banks showed evidences of caving, they were cleared for an average distance of 40 feet back from the stream, but where they were stable, only the overhanging trees were cut. This work was carried down-stream to Alban's Canal No. 2, a distance of 32 miles, where it was suspended February 25, on account of heavy rains and a sudden rise. The following is a summary of the work done:

Snags and logs removed from channel	30
Stumps and shore snags removed	239
Jams removed	1
Leaning trees cut	5,553
Trees girdled	2,637

The United States snag-boat *Florence* and the dredge *Lone Star* in command of M. B. Lydon, left Shreveport March 10 to complete the removal of the tow-heads near Rush Point. Dredging at Island No. 1 was resumed March 13, the *Florence* being employed at the same time in clearing a jam at the head of the island. The obstructions were removed thoroughly by March 16, and there is no probability of any trouble with jams at this point in future. After completing this work the boats went below Shreveport to Young's Point, to widen and deepen a cut-off made by planters of that vicinity. This was finished March 27, and the boats were returned to Shreveport and laid up the remainder of the month.

In April the *Florence* was employed in patrolling the river between the mouth of Loggy Bayou and the head of raft, breaking jams, etc. A flood stage, strong current, crevasses, and high winds rendered this work difficult and dangerous. The drift jammed eight different times, and only by repeated and persistent efforts was the river kept open to navigation. On the 2nd of May, 2 jams and 2 side jams were removed in the old raft region, and June 13 and 14 the boat was again called out to remove a jam at East Egypt. The following is a summary of the work of the *Florence* and the dredge:

Snags pulled	89
Stumps pulled	29
Logs removed from channel	220
Jams removed	12
Side jams removed	71
Leaning trees cut	60
Cubic yards earth dredged at tow-head and cut-off	10,450

In the latter part of April and early part of May, Red River had a disastrous flood, breaking the levees, overflowing adjacent lands, wash-

ing out railroads, and destroying crops and a great number of live stock. On the 5th of May I telegraphed the Department the condition of affairs, and on the following day received an answer stating that the Secretary of War approved the use of the snag-boats to save life and relieve suffering. The *Florence* was in commission at the time, and was ordered to render the people all the assistance possible. The *Howell*, the largest boat, was got ready May 8 to go to Chalk Level, a few miles below Shreveport, to relieve distress in that neighborhood, but through mismanagement of the pilot failed to pass the draw of the Shreveport Bridge, the port bow glancing against one of the piers, and the boat was swept by the strong cross-current partly under the bridge, knocking down her chimneys, and otherwise disabling the vessel. The *Wagner* was brought out the following morning to rescue the *Howell*, but her boiler burst before anything could be done. The only vessel then available for a relief boat was the *Florence*, which, under command of M. B. Lydon, rendered efficient service both above and below Shreveport, aiding 217 people in reaching high lands and rescuing 120 head of stock. This work was continued till May 10, when, the danger of overflow being over, the boat returned to Shreveport and pulled the *Howell* from the bridge.

The damages to the *Howell* and *Wagner* are being repaired. The cost of the former probably will not exceed $3,000, and the latter will amount to about $1,500.

ALEXANDRIA HARBOR.

I repeat below my report to the Department of February 28, 1890, which contains the latest information on the subject, and plan and estimate for further protection of the caving bank:

In compliance with request made by the Hon. N. C. Blanchard, and in accordance with instructions from Colonel Comstock, division engineer, I have the honor to report upon the survey of Red River at Alexandria, and the improvement of the city front of harbor at that place.

The work above Alexandria consisted in improving navigation over the upper and lower falls by cutting a channel through the rocky ledge forming them, depositing part of the excavated material in the old dam, and building a stone wing-dam from the west bank below to deflect the current from the city front.

Major Miller's project for the work on the harbor contemplated a mattress revetment of the west bank for a distance of about 3,000 feet, from the stone dam to Fish street, at a cost of about $15,000. His plan involved grading the bank to a slope of about 1 on 2½; but as this would have narrowed the street along the river front, required the construction of a new levee and the removal of the railroad track, and the destruction of property for which the owners demanded compensation amounting to about $5,500, a new project was made by Captain Bergland, October 24, 1884, approved by the Chief of Engineers, and the work finished in December, 1885.

In submitting his project to the Chief of Engineers, Captain Bergland said: There has been very little change in the low-water shore line since 1874 between Bayou Rapides and Madison street, while below Madison street the distance between the contours of the top of the bank and low water has lessened. These effects are probably due to erosion of the upper portion at time of high water, the bank there containing a large proportion of sand; and to the undermining action along the lower part, the bank there being stiff clay on a stratum of quick-sand overlying a soft sandstone at the zero water line. The erosion of the bank along the upper portion will probably cease on completion of the dam now under progress at the lower falls.

Captain Bergland's project was for the purpose of preventing the undermining of the lower stratum referred to above, and the work consisted of a crib superstructure on a broad crib foundation, and is described briefly as follows: A wing-dam, well secured to the west bank from below low water to the height of 10 feet above the zero of the gauge, making an angle of about 45° down-stream, and extending about 160 feet from shore, then running down-stream parallel to the shore for a distance of about 360 feet, the top of the work to be 10 feet above the zero. The cribs were built of round timber, filled with stone obtained near by, and the root of the dam secured

by riprap on the bank and on both sides below low water to prevent flanking. This form of construction was adopted to avoid the purchase or hire of plant, which would have been too expensive for so small a work; to permit deposit in the slackwater within the line of the work; to give a good foundation for raising the dam to a greater height if it should be found necessary; and finally to prevent the current from wearing away the soft rock available for filling. The estimate for the work was $14,309.15, but it cost somewhat more ($14,844.41), and was made about 80 feet shorter than planned. This was due to a sudden rise of 25 feet in three days, which put a stop to the work in December, 1884, and the engineer in charge was not able to resume construction till the following August. (Report Chief of Engineers '85, page 1478, and '86, page 1341.)

I have made several visits to Alexandria and have had the front examined and the reach surveyed twice since 1886. A map of the survey made by Assistant Craig was forwarded with the report for 1887, and the survey of February, 1890, is now being plotted on the same scale, $\frac{1}{2000}$. In my report for 1887 I said: "The caving on the Alexandria front, which caused so much anxiety to the property-owners, has not increased. It is impossible to say whether this is due to the fact that the river remained low for the greater part of last season and that no extraordinary high water followed, or that the caving had about reached its natural limit. No further work should be recommended at Alexandria until the completion of the survey from Fulton, Ark., to the mouth, unless it should be found necessary to straighten and widen the dredge-cuts through the upper falls, the passage of which is now somewhat difficult at extreme low water, on account of the deflection at the middle. A few points remain below Bailey's Dam that might be reduced with advantage; but on the whole the present channel does very well, except in extreme low water, and will accommodate boats that can now cross the bar above Red River Landing." (Report Chief of Engineers, 1887, p. 1445.)

I made a personal examination of the works of Alexandria last November, accompanied by Colonel Comstock, division engineer; the Hon. N. C. Blanchard, Representative in Congress from that district; the mayor of the city, and a number of citizens interested in the improvement. With the river at 8 feet on the gauge and rising there was a considerable area within the crib-dike just awash, and the bank behind not greatly changed since the survey, showing that the work had done what Captain Bergland had anticipated in planning it. I found that the people interested very generally desired work of the same kind, not as an extension of Captain Bergland's dike, but a repetition of it at an interval of 200 or 300 feet below. Colonel Comstock suggested that I should make an estimate of the cost of covering the bank with broken stone without mattress work, as is being tried with promise of success on some portions of the Mississippi River, and in the mean time I proposed to review the survey of 1886 as soon as the Red River survey should reach Alexandria. The field work of the survey was finished February 8 and the party brought into the office February 24. The map is now being plotted, and I have compared the shore-line with that of 1886 and find that there has been a slight caving of the bank below the crib-dam, amounting to less than 15 feet at most, during the past four years. While this is not great it is enough to cause uneasiness among the people of Alexandria, and justifies their request for further work.

With regard to the division engineer's suggestion to rip-rap the bank, say from its crest to below low-water mark, I have to say that I can not recommend it for the following reasons:

There is no stone in the neighborhood suitable for the purpose, that found in the falls and along shore being soft and easily worn away by the current when broken up. This was the reason that Captain Bergland built his work of cribs. Hard stone would have to be brought from a distance and up-stream, which would be very expensive, costing probably over $3 the yard. The bank being quite steep, would have to be graded, and this would involve land damages and contraction of the river-front as in Major Miller's project. I do not advise pile-work, because rock is indicated at varying depths below the bed, and is found above the surface near the bank below.

Captain Bergland's work has accomplished what it was intended to do, satisfies the people interested, and is probably best suited to the condition of affairs, as appears from the report of Assistant Engineer Marshall of February 28, given below:

"When the party reached Alexandria the last of January, the survey of 1886 was retraced as to shore-lines and soundings, and the results are now being mapped. The stage of water was too high to develop the effect of work heretofore done as fully as is to be desired, but it is plain the banks no longer cave within the influence of the dams built by the United States. The mayor and several prominent citizens most interested expressed an earnest desire to have the crib-dam built by the United States below the mouth of Bayou Rapides duplicated a little lower down. I suggested to them that a repetition of the dam below the first would probably cause a bar formation in front of their wharf, and, notwithstanding the declaration that they would not object, I would advise that if another dam is built it should not extend as far from

the bank as the first one does. The cost would be about the same as the former, and as the same objection to the other plans obtains now as then, and the result of the work has been satisfactory, the plan, in my opinion, should be repeated."

I concur in the opinion of Assistant Engineer Marshall, who laid out the original work, and I recommend the new work, as suggested by him and for the reasons given by me above, and for another important reason which should not be overlooked, namely, that such work will not interfere with any plans that may be adopted hereafter for the permanent improvement of Red River. Captain Bergland's estimate was $15,000, and the work, though some 80 feet less than planned, cost within $160 of that amount; but as he was delayed about eight months by high water, it is probable that a greater length of dike can be built for that amount if the material is collected in advance and the work prosecuted during the low-water season. I recommend also that the old work be repaired, and that both be raised to a height of about 15 feet above the zero, if it should be thought best upon examining the bank at the next low water, and accordingly estimate $15,000 for the new work and $7,500 for raising the whole to a higher level, or in all $22,500.

CYPRESS BAYOU.

The act of August 11, 1888, specified that of the appropriation for Red River, "five thousand dollars, or so much thereof as may be necessary, be used upon Cypress Bayou and the lakes between Shreveport, Louisiana, and Jefferson, Texas."

The improvement of this route was carried on before under separate specific appropriations, $112,000 having been appropriated from 1872 to 1886.

The project for the expenditure of the allotment of $5,000 contemplated straightening the channel through Fairy Lake and removing stumps, etc., to secure greater depth, removing stumps from the channel through Sodo Lake, clearing Twelve-Mile Bayou of snags and leaning timber, and dredging at various places.

The work in Twelve-Mile Bayou was reported by steam-boat men as of first importance, and the obstructions were removed in the fiscal year 1889 at a cost of $1,755.45.

Operations for the past fiscal year were as follows:

The United States snag-boat *Florence* and the dredge *Lone Star*, under command of M. B. Lydon, left Shreveport December 27 to resume operations on this improvement. On the 21st work was commenced just above Albany Flats, at what is known as the "Gate Posts," one of the shallowest places in the lakes, and a cut 827 feet long and 42 feet wide, giving a better channel, with an increased depth of 2½ feet, was completed into Blind Bayou January 9. A bad bend in the route through Blind Bayou was cut through next, and owing to delays by breakages, etc., was not finished until the 17th. The dredge was then towed to Cypress Bayou, where it was employed until March 6 in widening and deepening the cuts, notably at Boone's Bend, Burney Island, and Bois D'Arc Pass. The *Florence* was used to assist the dredge and tow it from one place to another, for the removal of snags, stumps, leaning trees, etc., and in marking the cleared channel through the lake with sign-boards.

Owing to scarcity of fuel the crew of the snag-boat was compelled frequently to cut wood for both boats, and in some instances to transport it 5 or 6 miles to the dredge. On March 6 the dredge, having accomplished all that could be done in the bayou at the stage of water, was taken in tow by the *Florence*. The next day was spent in widening the cut at the "Gate Posts," and on March 8 the boats returned to the fleet at Shreveport. The amount expended during the year was $2,918.73, leaving a balance available of $325.82.

The following is a summary of the work done:

Cubic yards earth, etc., dredged from channel	26,359
Snags pulled	61
Stumps pulled	138
Logs and trees removed from channel	53
Leaning trees cut	4,222
Leaning trees topped	122
Trees girdled	248
Square yards brush and willows cut	950
Trees towed from Little Willow Pass into lake	378

This water route is navigable from seven to nine months of the year, according to stages of water in Red River, the New Orleans packets usually transferring to smaller boats at Shreveport. The people of Jefferson and others desirous of reviving through steam-boat trade with New Orleans are very anxious to secure deep-water navigation throughout the year, and in February last I was directed to report on a resolution of the House of Representatives, dated February 9, 1890, requesting the Secretary of War—

To furnish to the House of Representatives at as early a day as may be practicable all information that may be obtained in his Department in relation to the improvement of Cypress Bayou and the lakes between Jefferson, Texas, and Shreveport, in the State of Louisiana; and that he make such suggestions as he may see proper for the improvement of such bayou and lakes, and the amount necessary to accomplish the same.

My report was submitted February 26 and published in House Ex. Doc. No. 252, Fifty-first Congress, first session. (See Appendix W 18.) The plan which it is desired to have investigated consists essentially of the formation of a reservoir in the bayou proper and the lakes, by constructing a dam and lock at the head of Sodo Lake and dredging a channel through the latter to Twelve-Mile Bayou or to Red River. The feasibility of this plan can not be discussed until a thorough survey is made, both in topography and precise levels, and the survey of Red River completed and a plan of improvement adopted that will insure a low-water channel of at least 5 feet from Shreveport to the Mississippi. It is impossible to estimate the cost of or formulate a plan for slack-water navigation between Shreveport and Jefferson from the surveys and examinations made during the raft period, and as the country is a very difficult one, I estimate the cost of the survey at $10,000, or $12,000, if it is found necessary to examine the outlets between this route and Upper Red River.

In the mean time the sum of $15,000 can be used to advantage in dredging and removing obstructions, or, say, $10,000 in the fiscal year 1892 and $5,000 in 1893, while awaiting the results of the survey, and the work will be beneficial whether the lock and dam project is carried out or not.

BAYOU DORCHEAT.

The act of August 11, 1888, provided that $5,000, or so much thereof as might be necessary, of the appropriation for improving Red River, be applied to improvement of Bayou Dorcheat. A specific appropriation of $5,000 for this work was made by the river and harbor act of 1884, and the most serious obstructions to high-water navigation between Murrell's Point on the Dorcheat and the mouth of Loggy Bayou, 71 miles below, were removed with this amount (p. 1496, Report Chief of Engineers, 1885).

The plan for expenditure of the allotment by the act of 1888 contem-

plated going over the work, cutting the brush which had grown since 1884, and removing dangerous stumps, leaning timber, etc.

Operations were commenced in the Dorcheat in May, 1889, with the snag-boat *Harry Breck*, and continued down-stream to the close of the fiscal year. The amount expended to June 30, 1889, was $1,575.83.

In the past year work was continued as follows:

The snag-boat *Breck* continued work down-stream, clearing the channel through Lake Bistenau, and removing snags, etc., and cutting leaning timber along Loggy Bayou. The old outlet from the lake into Loggy Bayou had shoaled until it was impassable, and was closed with brush dams. A new outlet was cleared and excavated, the course of the water turned into it by means of brush wing-dams, and it soon scoured to a sufficient depth and width, the overseer in charge reporting that it had an average depth of 3½ feet at extreme low water. Work in Loggy Bayou was completed September 7 and the snag-boat was returned to the fleet at Shreveport. After finishing this work a chopping party was organized to clear the obstructions immediately below Minden Landing, which part of the Dorcheat could not be reached with the boat on account of the low stages of water. Work commenced at the landing September 16 and was completed October 9. The following is a summary of the work done during the year.

Snags pulled	23
Logs removed from channel	89
Stumps removed	652
Large bowlders removed from channel, Loggy Bayou	2
Fish traps destroyed	2
Shore snags cut	114
Leaning trees removed	1,209
Leaning trees topped	21
Trees girdled	1,285
Square yards brush and willows cut	231,710
Cubic yards of earth excavated at outlet	894
Linear feet brush dams built	135

It is believed that this work accomplished all that should be done for many years to come. Navigation to Minden has been made practicable at high stages of Red River, and to lengthen the navigation season would necessitate dredging at the bars and narrow places, the cost of which is not commensurate with the limited commerce to be benefited.

Regarding the benefits derived from the improvement, Overseer W. W. Moore reports as follows:

> The work done has put the stream in good navigable condition, and I do not consider that anything further will be required for years. I do not think that Bayou Dorcheat will be used for navigation, as the merchants of Minden, in consideration of certain rates of freight given them by the Vicksburg, Shreveport and Pacific Railroad, have agreed not to patronize steam-boats. This, however, does not apply to Loggy Bayou and Lake Bistenau, as I am informed that since the improvement has been accomplished two New Orleans firms are engaged in getting out vast quantities of oak staves along their banks, where the finest timber abounds, and that two small steam-boats will navigate the stream this season.

The amount expended during the fiscal year was $1,999.16. The unexpended balance of $1,425.01 not being needed for this work, will be transferred to the "general improvement" of Red River.

The permanent improvement of Red River offers a problem of exceeding difficulty, the solution of which depends upon certain conditions that exist in no other stream in like degree. The most serious question is the disposition of drift, which runs at times in such quantities as to render navigation hazardous by day and impossible by night. The river is frequently jammed in a few hours with acres of snags and logs;

and raft formation is prevented only by prompt service of the snag-boats. Should jams occur when funds are exhausted and none expected for some time, it is probable that new rafts would form, diverting the river from the bed in which thousands have been judiciously spent, to lose itself in the low lands and bayous, destroying by the way a fertile country that has been reclaimed from overflow by the joint work of the improvement and the construction of levees by the State. Should the survey of Red River now in progress from Fulton to the Atchafalaya indicate that a slackwater system is feasible and for the best interests of navigation, the question of drift would assume larger proportions, possibly even prohibitory. There can be little doubt that it would forbid the general application of any existing system of movable dams; and even with fixed dams the question remains a serious one.

Some means would have to be devised to catch drift, keep it out of the channel-way and locks, and this would necessitate very long guard-walls, with traveling cranes to handle heavy timber. Possibly a combination of two systems might be made, giving a drift pass to be closed by heavy shutters, bear-trap, or other device drawn from the best experience on such work.

An open river, however, even with occasional detentions in low water, is to be preferred to any slack-water system with detentions at every lock, if it can be made to give generally a fair navigation throughout the year at a reasonable cost, and its permanency secured by a moderate percentage for maintenance. The importance of the subject can be judged best by referring to the map of the country drained by Red, Ouachita, and tributary streams. Cheap transportation for the entire valley west of Mississippi and south of the Arkansas is possible only through the mouth of Red River to the port of New Orleans and the sea.

Whatever plan shall be adopted for improving the main rivers, or even if the work of giving an assured reasonable navigation in Red River to Shreveport and beyond be delayed for a time, there are certain general principles to be followed, if only to save, till that time comes, what has been gained or to prevent the river closing. These principles are stated in natural sequence, as follows:

1. The systematic clearing of the banks for some distance back far beyond the limits of this district. It is cheaper to remove the source of drift than to dispose of drift; and the benefit to navigation is immediate.

2. An efficient snag-boat service for general work, patroling the river, preventing jams, removing logs and snags from the channel and banks, and dredging tow-heads and obstinate shoals. Here, again, the benefit is immediate. A permanent appropriation of not less than $25,000 a year is needed for this purpose.

3. Extending the scope of the survey to embrace the whole valley. This is necessary to a proper study of this river and tributaries, and to furnish all the information required to decide upon a system of improvement and to locate its elements.

4. Construction of a substantial system of levees to restrain the greatest floods, either alone or in partnership with the riparian States.

5. Closing gradually every outlet through which the main streams are depleted at various stages above low water.

6. Fixing caving banks to confine the main stream to the channel selected for it.

7. To exercise a watchful care from first to last to prevent injury to the regimen of the streams by cut-offs or outlets, and to keep the building of bridges within reasonable bounds.

SURVEY OF RED RIVER FROM FULTON, ARKANSAS, TO ATCHAFALAYA RIVER.

Field work was carried on during July, 1889, but, as foreshadowed in the last report, sickness in the parties and general unhealthy conditions in the valley caused the work to be suspended at the end of the month. Three assistants and a draughtsman were retained for computations and maps. The parties were reorganized about the middle of October, and the survey carried down-stream below Alexandria by the middle of February, when field work was suspended, the quarter-boats laid up at the commission fleet, and only a small force retained in the office to work up the notes. The work has progressed satisfactorily, but a great deal still remains to be done. About 100 miles of the lower river have to be surveyed, a part of the lines revised between Shreveport and Caspiana in the portion known as the "Little River," and connections made with the survey of Bayon Pierre, including the much-discussed "Tone's Bayou."

Assistant Engineer H. M. Marshall had charge throughout the year, and conducted operations with enterprise and ability. He was fortunate in securing excellent assistants, whose names appear on the several tables and plates accompanying this report.

Practical experience with the base-apparatus first discussed in Report Chief of Engineers, 1889, page 1592, suggested some changes in the verniers and frames to allow simultaneous lateral and vertical motion and alignment. The verniers were modified at small cost and the apparatus is now believed to be complete. Tests of specimens of both tapes, kindly made by Colonel Flagler, commanding Watertown Arsenal, indicate somewhat larger section to insure a greater factor of safety for the brass tape, and as both tapes should be as near the same dimensions as possible, it may be necessary to have new ones made. The method of reeling is not satisfactory, and I propose to substitute for the sheaves large grooved-paper drums in boxes of diameters and lengths to hold the tapes without overlapping. This plant will prevent kinking, keep the tapes in place under a low tension, and allow easy cleaning.

I have made the general designs for the drums and traveling device for holding the tape in reeling, but they will not be ordered until certain additional tests now making at the arsenal have been discussed, and the section for the tapes determined. From the results obtained with the present tapes it is believed that with the proposed changes a high degree of accuracy can be obtained by this method, and it is not improbable that the results will compare favorably with those obtained with more expensive and complicated apparatus. This much may be said in regard to the two-tape method:

The apparatus is simple, compact, strong, and light, and can be carried in boxes as easily as other field instruments. No thermometers are required, unless the observer wishes to satisfy himself of the agreement of practice and theory. The number of men needed is less and the time required to measure a base, say of 2 miles, twice over should not exceed one working day. The cost of a complete apparatus is estimated at $350, exclusive of the expense of standardizing the tapes. For this purpose the first tape would require to be determined by a standard base; the others can be derived from the first. Comparing this method with that by rods or tubes, the following is to be remarked with regard to errors of observation: While each contact with rods is observed with a superior nicety, the number of contacts for each tape length is less

than that for the same distance covered by the rods by twice the inverse ratio of tape-length to rod length, less two, or for any base by twice the difference between the number of rod and tape lengths required to measure it. As the resultant error is proportional to the square root of the number of contacts, approximately, the error of one contact multiplied by two-thirds the square root of the number of contacts, the error of contact of the tapes may be as much greater than the error of the *finer* contact of the rods as the square root of the length of the tape is greater than the square root of the length of the rod, and yet the length of the base be determined with equal exactness.

To determine the lengths of the steel and brass tapes, the United States Coast and Geodetic Survey base at Delta, La., was taken as standard. This base was established and measured by that Department in 1878, with 6-meter contact-slide-rods, and is about 2,700 meters long. After the party had been thoroughly drilled for several days three measurements were made on the nights of April 9, 10, and 11, the last being accomplished in about four hours' continuous work.

The verniers read to one-tenth millimeter or say one-millionth of the tape-length; there were 54 contacts, the standard marks or zeroes having been set purposely slightly more than 100 meters apart by the use of a Chesterman steel tape, to make the number of shifts twenty-seven, and the resultant mean length of the steel tape at 60° Fahrenheit was found to be 100.6130 meters, with a mean square error of twenty-six thousanths millimeter. That is to say, if the steel tape is stretched by a constant tension of 16 pounds on the balance beam, at 60° Fahrenheit, although it will assume the form of successive catenaries of small versedsines, the distance between two points covered by the zeros will be 100,6130 meters $\times$ 0.018 millimeter, the Delta base being standard. The length of the brass tape was determined by successive comparisons with the steel tape, compared thermometers having been used in the first measurements and in the comparisons. Both tapes were used simultaneously in measuring the base on Red River.

It is proposed to check the length thus obtained by measuring the Coast Survey base near Red Liver Landing and immediately remeasure the Delta base, after which, if found to be required, new tapes can be made of larger sections and their length determined by the standard base.

It is proper to express here our obligation to Colonel Flagler, of the Ordnance Department, for the careful tests made under his direction, and to the officers of the U. S. Coast and Geodetic Survey for suggestions and fine work in graduating the tapes, and for prompt courtesy in sending valuable and necessary information at various times.

The experimental apparatus and method are described in Assistant Engineer Marshall's report and in the plates, and a full discussion of the formulas developed by him is given, with examples of the record and the tabulated results.

Attention is invited to the table of results in precise leveling, which are quite within the usual limits. The work is divided into two parts, one table giving the line, about 170 miles long, run east and west to Shreveport from the U. S. Coast and Geodetic precise bench No. 215 at Delta, and the other the lines run on Red River in a generally north and south direction. It is regretted that the work could not have been carried through to the precise bench near Red River Landing and so connect with the main line on Mississippi River and complete the loop and publish the result as a whole. It will now take about four months to finish the levels and reduce the computations.

Incidentally this work has been of great benefit to the district in giving permanent points at every tributary in Louisiana crossed by the Vicksburg and Shreveport Railroad, forming starting points for determining their rise and fall and slopes and bringing them into the general system of the commission surveys. The whole country near the level lines will be benefited also, as permanent monuments have been set at short intervals, which local boards and surveyors can use in finding the limits of overflow and in draining their lands. The levee boards will find the permanent benches invaluable in fixing grade-lines, and finally the Vicksburg and Shreveport Railway Company has secured a datum by which its road-bed can be put at a safe elevation. This company gave a valuable equivalent for the service by furnishing an engineer's car, supply and cooking car, and hand car, and hauling the same as required, without charge.

The descriptions of bench-marks and of triangulation and other points are supplemented by sketches given on the plates. This method has been adopted to save time in furnishing information that is frequently called for and which almost invariably interferes with the regular work of the office.

The method of reducing soundings which has been used as far as Alexandria, is the best that could be devised under the circumstances. When the survey was started there was but one definite elevation on the river, namely, the zero of the gauge at Red River Landing at the mouth, which is 23.85 feet above Cairo datum, or 2.59 feet above the provisional mean gulf level of the Mississippi River Commission, and it was not until precise levels reached Shreveport that other points could be established. Had we been able to carry precise levels down-stream to the mouth before taking soundings, low-water could have been determined at as many stations as desired, a profile of which would have given a limiting line of low waters, or approximately the low-water slope to which all soundings could be reduced. It is preferable, however, to correct all soundings as if taken at a mean stage, say, for convenience, 10 feet above the low-water line. Soundings recorded as taken in a stream subject to such fluctuations as is Red River are misleading unless the dates and gauge-curves are given on the maps, and this requires a tedious calculation to be made whenever it is desired to compare the recorded soundings with those taken at any other time. But soundings arbitrarily reduced to low water are still more misleading, because the resulting contours must indicate a condition of affairs which it is almost certain could not exist. By taking 10 feet as a mean stage above the low-water slope, a ready way is given for determining what might be the minimum depth, bearing in mind that in an alluvial stream the low-water channel must cut through the bars and give a greater depth so long as the river flows.

The scope of the survey has been extended as the work progressed and as our knowledge of Red River grew. With the exception of the reconnaissance of 1806 there was no extended survey or map of Red River. Its length was unknown, the distance from Shreveport to the Mississippi having been overestimated nearly 200 miles, and there was not a single definite elevation on the river above from which its fall could be determined. It is now certain that the original estimates for the reconnaissance which has developed into this survey were too small. Moreover, the importance of Red River as the principal water-way and outlet for a great inland system has grown more apparent as the work was extended, and it is now plain that whatever system shall be chosen

finally for its permanent improvement, an exhaustive survey is of the first necessity.

A report, with estimates for completing the survey, was transmitted February 28, 1890, by the Chief of Engineers to the chairman of the Committee on Rivers and Harbors, which is given in full below, with correspondence with the division engineer in regard to secondary triangulation. The estimate for that work and for the publication of charts might be omitted, but the additional amount is not too large to make the survey as complete as the importance of the subject demands, and therefore for these reasons and from the results obtained thus far, I am in favor of carrying out the approved project. The estimate of the special report is reduced however, by the amount expended since January 1, 1890, leaving $125,000 for the completion of this survey on a suitable scale, a sum hardly to be considered in comparison to the great interests involved and the probable cost of a plan for the permanent improvement of the river and the development of a great agricultural country.

LETTER OF THE CHIEF OF ENGINEERS.

OFFICE OF THE CHIEF OF ENGINEERS,
UNITED STATES ARMY,
Washington, D. C., February 28, 1890.

SIR: I am in receipt of your letter of yesterday's date, and to comply with request therein beg to transmit herewith copy of report dated January 10, 1890 (with accompanying papers), from Capt. J. H. Willard, Corps of Engineers, submitting revised estimate for completion of survey of Red River, Louisiana.

Very respectfully, your obedient servant,

THOS. LINCOLN CASEY,
Brig. Gen., Chief of Engineers.

Hon. THOS. J. HENDERSON,
Chairman Committee on Rivers and Harbors.

LETTER OF CAPT. JOSEPH H. WILLARD, CORPS OF ENGINEERS.

UNITED STATES ENGINEER OFFICE,
Vicksburg, Miss., January 10, 1890.

GENERAL: I have the honor to report that after making a trip down Red River, Louisiana, from Shreveport to the Atchafalaya, for the purpose of examining the work of the survey and inspecting the harbors of Shreveport and Alexandria and the general condition of the river, I directed Assistant Engineer Marshall, in charge of the survey, to make an estimate for completing it. The original estimate was submitted with the idea of making a careful reconnaissance rather than a high-grade survey, but the work has developed as it progressed, and is now prosecuted in the same way as the surveys on the Mississippi and Missouri rivers, with the expectation of obtaining results that will be permanent or good for many years.

The change of plan is fully justified by the importance of the stream as a part of a great system of interior water-ways involving Red River itself from above Fulton, Ark., the limit of my district, and its tributaries, and Ouachita and the streams flowing into the latter, especially between it and Mississippi River, and is in accordance with the adopted project, which is summarized in my last report, page 1592, Report of the Chief of Engineers for 1889. Assistant Engineer Marshall's estimates were made in the field and derived chiefly from the progress of the parties under him, and agree practically with the results of similar work under the commissions.

The estimates for publishing maps are not easy to make, and the actual cost can be got only by submitting a finished sheet to firms that have been engaged on such work for the Department. The Mississippi River Commission maps cost about as follows: The inch-mile map, $55 the sheet, edition 1,500 copies; the 20,000 scale, $145 the sheet, edition 1,000 copies; and the original 10,000 scale sheets, $202 each, on a very close estimate, before mechanical devices were used to save labor on topography, when

the cost was reduced to $142 the sheet. The amounts per kilometer for each kind of work given by Assistant Engineer Marshall accord very well with those per mile submitted by me in a late report putting the cost of the survey of Ouachita River at $150,000, but to cover delays from sickness or protracted high water, I think the total estimate should be greater than his. The secondary triangulation may require high stations or considerable felling of timber in the thickly wooded portions, and discharge observations as a rule can not be carried on continuously, but are subject to many interruptions. In my judgment, the items for discharge observations, secondary triangulation, and printing maps should be increased by $4,000, $10,000, and $5,000 each, making the total estimate $125,000.

The object of this survey is to obtain full information about Red River, upon which to base a plan for its general improvement, and the estimates submitted, not large considering the importance of the stream, are intended to cover work during two seasons in the field, office work when operations are interrupted and at the close of the survey, and publication of charts for general use and issue, and economy both in money and time will be subserved best by granting the full amount, so that the work can be continued and finished under the same organization. I have discussed the matter very thoroughly with Assistant Engineer Marshall since receiving his report, and have decided to call in the field parties about the end of the month and expend the remainder of the appropriation on the notes and field sheets, in order to secure the results already obtained. Indeed, it may be necessary to suspend operations before reaching Alexandria, as Red River and Ouachita are rising fast from the late heavy rains in the Southwest.

My letter of instructions to Assistant Engineer Marshall and his report in answer are given in full below.

UNITED STATES ENGINEER OFFICE,
Vicksburg, Miss., December 11, 1889.

Sir: The balance available for continuing the survey of Red River will be about $8,000 on the first of January, 1890. Having recently gone over the river from Shreveport to the Mississippi, I am convinced that this sum will be insufficient to complete the survey. The obstacles to rapid progress will increase as you come down the stream, and the cost of the secondary triangulation will exceed former estimates, as it will require either a great amount of cutting through swamps and timber or the erection of high stations, probably not a little of both. I wish, therefore, you would make a careful estimate of the amount of work you can do with this sum and a separate estimate for completing the survey. The latter should cover all the field work, secondary and tertiary triangulation, precise levels, and monuments, topography, hydrography, current and sediment observations, transvalley sections, borings, etc., and all office work, computations, projection of maps, and finally the probable cost of publishing the work in atlas form for general use, like those of the Mississippi, Arkansas, and other rivers. The information must be so full and complete as not to require another survey for many years, and I want the estimates to cover all contingencies, floods, etc., so that another appropriation need not be asked for.

In regard to the last item, I think the scale of our field sheets, 1:10,000, will be the best to adopt. The cost of printing the maps should not be greatly above that of maps on 1:15,000 or smaller scale, and the difference would doubtless be saved in the time and expense required to reduce the final sheets from the field to the smaller scale. The scale of 1:10,000 will give a good general working map for the river improvements and one for the use of navigation on a comparatively large scale without being unhandy, and thus obviate the necessity of two sets of charts.

Please send in your estimates without delay, together with suggestions you may find convenient.

Very respectfully,

J. H. WILLARD,
Captain, Corps of Engineers.

Assistant Engineer MARSHALL,
In Charge of Survey of Red River, La.

RED RIVER SURVEY, *December* 20, 1889.

Sir: In compliance with your instructions I beg to submit the following report of progress and estimate for completion of survey of Red River.

Since report for the fiscal year ending June 30, 1889, field work has been carried from Caspiana Landing, 70.4 kilometers (44 miles) below Shreveport, to Derlouche, 272 kilometers (170 miles) below Shreveport. The parties were withdrawn from the field on account of sickness from August 1 to October 15, and three assistants and a draughtsman were employed in the office making reduction of notes and checking field computations. By January 1, 1890, the survey will have about reached Colfax,

about 232 kilometers (145 miles) above the head of Atchafalaya River, and with $8,000, balance available, can be carried to about Cassandria, 96 kilometers (60 miles), thus leaving 120 kilometers (75 miles), which at $100 per kilometer ($160 per mile), that being the cost of topographical work alone on the Mississippi River, would require $12,000. The above rate, while considerably over the cost of work done this season, is justified by the increased difficulties to be encountered in the unsettled timbered country through which that part of the river flows.

The following is a summary of the work now done, and to be done there, with an estimate of the cost of the latter:

WORK DONE.

Number of bases measured	2
Number of observations for azimuth	3
Number of triangles observed	164
Number of hectares of topography (233.3 square miles)	59,740
Number of hectares of hydrography (12.3 square miles)	3,140
Total area surveyed, hectares (245.6 square miles)	62,880
Precise level run in duplicate, kilometers (78.8 miles)	126.1
Length of river surveyed, kilometers (131 miles)	209.6

WORK TO BE DONE.

120 kilometers topography, hydrography, and precise level, at $100	$12,000
138 kilometers transvalley sections (eight in number), with borings	8,000
High and low water discharge, slope and sediment observations	6,000
Computation and projection of maps	5,000
800 kilometers (500 miles) secondary triangulation, from Atchafalaya River to Fulton, at $75	60,000
Publishing 500 charts (100 sheets each) on a scale of 1:10,000	15,000
Total for completion of survey	106,000

The estimate for publishing is very uncertain, as I can not get any information on the subject from reports here, and publishers' charges are variable. I respectfully suggest that when the field work shall have reached Alexandria, or on January 31, the party be withdrawn from the field and the draughtsman and two assistants be retained in the office to reduce and tabulate the results of the work with which they are familiar, and complete the sheets which have been plotted in pencil, on a scale of 1:10,000. There are already thirty-eight large sheets (26 by 34 inches) and two smaller ones, showing all lines and most of the topography of the survey.

Very respectfully, your obedient servant,

H. M. MARSHALL,
Assistant Engineer.

Capt. J. H. WILLARD,
Corps of Engineers, U. S. A.

Money statement.

July 1, 1889, amount available		$21,111.00
January 1, 1890, amount expended since	$13,119.00	
January 1, 1890, outstanding liabilities	11.00	
		13,130.00
January 1, 1890, balance available		7,981.72
Amount (estimated) required for completion of the existing project		125,000.00
Amount that can be profitably expended in fiscal year ending June 30, 1891		132,981.72
Submitted in compliance with requirements of sections 2 of river and harbor acts of 1866 and 1867.		

Very respectfully, your obedient servant,

J. H. WILLARD,
Captain, Corps of Engineers.

Brig. Gen. THOMAS L. CASEY,
Chief of Engineers, U. S. A.

LETTER OF THE DIVISION ENGINEER.

UNITED STATES ENGINEER OFFICE,
New York City, January 13, 1890.

SIR: Your estimate of January 11, 1890, of the cost of finishing the Red River survey is received. The cost of the secondary triangulation from Fulton to the Atchafalaya, 500 miles, at $120, is great, and the question arises whether on a river as narrow and wooded as much of the Red River is, *equal* accuracy can not be obtained by another method at less expense. I do not suppose the accuracy in the length of your triangle sides, when you are ten triangles away from your bases, will exceed or equal one ten-thousandth part of those lengths.

Suppose you were to run straight azimuth lines, 1 to 5 miles long, crossing necks wherever practicable, measuring the length of these lines with a steel tape to within one ten-thousandth part, and the angles of these lines with the same accuracy as those of a secondary triangulation, the junctions of azimuth lines should be determined with an accuracy of about one ten-thousandth. On these junction points depend the stadia survey of the intervening stretches of river, which might be from 1 to 10 miles long.

Could not lines be cut (where necessary), measured with a steel tape, and angles of azimuth lines read, at much less than $120 per mile? High stations, if heavy, so as to give accurate angles, are very costly and would thus be avoided.

Where the country is open and high stations are not needed, triangulation would probably be cheaper if large triangles could be got, but not much more accurate.

If the azimuth-line method were tried, astronomical azimuths should be determined once in 20 or 30 miles, and latitude determinations made at about four prominent points as checks.

Will you submit an estimate of the cost of such azimuth-line survey from Fulton to Atchafalaya, with your views upon it.

Very respectfully, your obedient servant,

C. B. COMSTOCK,
Colonel of Engineers, Bvt. Brig. Gen., U. S. A.,
Division Engineer.

Capt. J. H. WILLARD,
Corps of Engineers, U. S. A.

LETTER OF MR. H. M. MARSHALL, ASSISTANT ENGINEER.

QUARTERBOAT No. 2, RED RIVER SURVEY, *January* 20, 1890.

SIR: Mr. Roof sent me a copy of General Comstock's letter and suggested that you might want to hear from me. I beg to submit the following:

To attain an accuracy of one ten-thousandth, using a tape 100 feet in length, requires an error not greater than 0.01 foot in a single tape's length. In open air this would necessitate a steady, uniform pull, and that the tape be supported at least at the middle, and the marks at each tape's length be made with a fine point on a firm surface, which would require three stakes each tape length; a difference of 1 foot in elevation between stakes would require a correction of 0.01, therefore levels must be run over the stakes. A variation from standard temperature of 15 degrees would itself, if uncorrected, cause an error of 1 in 10,000. Hence there would be 4 laborers, at $30, cutting out line; 1 instrument man, at $100, and 1 rodman, at $60, keeping alignment; 2 laborers, at $30, setting and driving stakes; 2 laborers, at $30, stretching tape; 1 laborer, at $30, at middle of tape; 1 laborer, at $30, resetting end stake, and 2 recorders, at $75, marking ends of tape lengths and reading thermometers; 1 leveler, at $100, and 1 laborer, at $30, leveling over stakes, which gives the following cost per month:

Two instrument men, at $100	$200
Two recorders, at $75	150
One rodman, at $60	60
Eleven laborers, at $30	330
One cook, at $50	50
One waiter, at $15	15
Eighteen men's subsistence, at $15	270
Total	1,075

The bases measured on this survey have been in open meadow, and have been 500 to 600 meters long, and it has taken a day to set the stakes and make the measurements in just the same way these azimuth lines would be, except perhaps more care

was taken. The number of men employed has been only eight to ten, but in rough ground the greater number of men now estimated for will hardly progress faster, and when the amount of rough timbered country is taken into account half a mile per working day, twice measured line, or 13 miles per month, is all that may be expected, giving $82.69 cost per mile. If to this be added office work and superintendence the cost will be $95 to $100 per mile. Straight lines of a mile in length could be obtained, so that it would be practical to measure them, but no straight line 5 miles long can be measured along Red River without crossing sloughs, lakes, and swamps that would require bridging at a cost of thousands of dollars. With the number of azimuth lines so greatly increased, the error at junctions would be considerable, and to this add the error arising from the inaccuracy of running straight lines, and the error in azimuth would soon pass far beyond the limit, and in polar co-ordinates an error in azimuth is quite as important as an error in distance. So far as a check on the stadia work is concerned the tertiary work already done is believed to be more accurate than any system of azimuth lines that can be run at a reasonable cost, and ample for that purpose; but when the plan was submitted it was conceived to be desirable to ascertain the position of points in Red River Valley with that degree of accuracy usually obtained in geodetic work; therefore provision was made for a secondary system of triangulation, taking in the bluffs on either side.

The system having sides from 5 to 7 miles long, angles measured by instruments reading to 10 seconds should not be in error more than 6.7 seconds, which in a well-conditioned triangle would give an error in the sine of the angle of 8 in the sixth place of the logarithm; that in the side (10,000 M.) would correspond to an error of .2 M., or 1 in 50,000, and after going through thirty angles, ten triangles, the accumulated error should be probably 1.09 M., covering a country 50,000 M. long. By proposed azimuth line the accumulated error in distance alone would be probably 5 M. The estimated cost of secondary work on Missouri River, after a good deal of experience, is given (Chief of Engineers' Report, 1888, page 2,319) at $90 per mile. In the estimate heretofore sent in for Red River $10 per mile was added as cost of office reduction and the other $20 to insure completion of the survey within the estimate regardless of contingencies.

Very respectfully, your obedient servant,

H. M. MARSHALL,
Assistant Engineer.

Capt. J. H. WILLARD,
Corps of Engineers, U. S. A.

LETTER OF CAPTAIN JOSEPH H. WILLARD, CORPS OF ENGINEERS.

UNITED STATES ENGINEER OFFICE,
Vicksburg, Miss., February 6, 1890.

SIR: Your letter of January 13, 1890, referring to my estimate of January 11 for completing the survey of Red River was received January 17, during my absence on a tour of inspection of Ouachita River, Louisiana. The chief clerk referred it at once to Assistant Engineer Marshall, who has charge of the survey in the field, and I inclose a copy of his reply to which I invite your attention.

The revised estimate was made upon the basis of the approved project which contemplates secondary triangulation, and I think it would be safest to continue the work in accordance with that plan. I hardly know how to compare the cost of secondary triangulation with that of the method by azimuths, but I presume the latter would have been cheaper if adopted in the beginning. To change to that method now would require a separate party to go over the whole line from Fulton to the Atchafalaya, and this would cost for field work about the same as the proposed triangulation. The unknown element of cost in both methods is the cutting of timber, and in the latter the construction of stations, and these can not be estimated until the topographical parties have reached the end of the survey. I believe that the system of triangulation can be adjusted so as to avoid construction of many high stations, and as for cutting timber the cost would probably be quite as great for azimuth lines as for triangulation. I should prefer therefore to conduct the work as planned, carrying on the secondary triangulation by an independent party, and giving the others the sections and gangings on completing the levels and topography. The estimate of $120 the mile is not large when it is understood to include field work, office computations, and all contingencies, and if it should be prosecuted under favorable conditions, and there should be no serious illness in Red River Valley, it is probable that the ultimate cost would be considerably less.

On the other hand, if the work should be suspended for a year or two, an increased allowance would have to be made for reorganization. My estimate is intended to finish the work upon a scale proportioned to the importance of the stream and with

the same degree of accuracy required on commission surveys, including the publication of general charts on a convenient scale. Now, it is a fact, proper to be noted, that appropriations for improving rivers and harbors have been made only every other year since August, 1882, and therefore I have not asked for an amount that could be expended economically during the next fiscal year, but for the full amount. The work can be made continuous only in this way.

I believe that a demand will be made within a few years for a systematic improvement of Red River and the streams tributary to give good navigation of at least 4 feet the year round, and when the demand is made the fullest information should be at hand for a proper discussion of plans. We have an opportunity now to collect the necessary information without haste, and to revise and correct errors as the work progresses, that is rarely allowed on public works of the United States, and I hope that we may be able to take advantage of it.

Considering the importance of the system of water lines in the southwest, of which Red River forms a great and controlling part, and considering the probable cost of a feasible plan for permanent improvement, I think my estimate for this survey economical and reasonable.

Very respectfully, your obedient servant,

J. H. WILLARD,
Captain, Corps of Engineers.

Col. C. B. COMSTOCK,
Corps of Engineers, U. S. A.,
Division Engineer, Southwest Division.

PROGRESS REPORT OF ASSISTANT ENGINEER HORACE M. MARSHALL ON THE SURVEY OF RED RIVER FROM FULTON, ARKANSAS, TO THE ATCHAFALAYA.

During the fiscal year work has advanced to Grand Bend, 650 kilometers (406 miles) below Fulton, leaving 150 kilometers (94 miles) to Atchafalaya yet unsurveyed. Composition of field parties was nearly the same as last year, and to the excellent work of Assistant Engineers T. C. Thomas, and T. G. Rombauer, in both field and office, is largely due whatever of credit pertains to the results. Field parties were withdrawn February 14, 1890, and three assistants, a draughtsman and two recorders retained in the office.

A description of methods with results obtained is given herewith under the heads: Base-measuring apparatus; triangulation; hypsometry; topography; and hydrography.

BASE-MEASURING APPARATUS.

Following the method under the Mississippi River Commission, which was further elaborated under the Missouri River Commission, of measuring base lines with tapes, it was desirable to perfect the method and reduce the bulk of instruments. Assistant Engineer O. B. Wheeler's remark, "It was believed that the main source of error was due to an uncertain temperature correction," being without doubt the true explanation of the difficulty to be overcome, use was made of a brass and a steel tape, whose difference in length, due to difference in rate of expansion, measured the temperature of the tapes themselves; the same thing on a different plan having been heretofore done by Professor Jäderin, of Stockholm.

To obtain as nearly the same section as practicable the tapes, which are about 100 meters long, were rolled under special order by J. A. Gowdey & Son, of Providence, R. I. Tests made under direction of Colonel Flagler, Ordnance Department, United States Army, at Watertown Arsenal, developed the following characteristics:

Tests of brass and steel tapes.

Characteristics.	Brass tape.	Steel tape.
Sectional dimensions (inch)	0.128 by 0.0128	0.129 by 0.0130
Sectional area (square inch)	0.0016	0.0017
Ratio of elongation (load, 40 pounds)	0.0008	0.0006
Ratio of set	0.0001	0.0001
Tensile strength (pounds per square inch)	60,000	227,650

That they might be subject to the same temperature, they were stretched side by side and measurement made simultaneously.

The United States Coast and Geodetic Survey Department very courteously graduated the tapes, without charge, displaying great skill in copper-plating the steel tape over the space occupied by the graduation, and in engraving on both tapes. The steel tape was standardized before graduation by using paper scales glued to the tape, and the length of the brass tape found by several comparisons at varying temperatures. Graduation extends both ways from the standard marks near the ends over a space of two decimeters divided to millimeters. The numbers run both ways from the zeroes. The tapes are kept and transported on reels about 15 inches in diameter, made like single sheaves with three-eighths inch opening, turning in a frame by a crank and handle. The instruments for applying and measuring tension are an adaptation of those used by Assistant Engineer Wheeler under the Missouri River Commission. The method and means of marking the ends of the tape length are believed to be original. In quick grasp of the ideas, and excellent workmanship in carrying out the designs, Messrs. W. and L. E. Gurley, of Troy, N. Y., exhibited pre-eminence in their calling, and aided in no small degree in the undertaking. The apparatus consists of:

1. Four tension frames;

2. Two balance beams.

Tension frame consists of a clamp and frame of brass shown in vertical projection side and end, and horizontal projection, Plate I. The clamp has two arms above it, to which is screwed the three-sided rectangular frame. A screw working in one end moves the brass block, which is guided by flanges sliding in grooves in the sides of the frame. The screw is attached to the block, as shown in section A B, by a collar, so that it will not be disengaged by turning. Two small hooks are screwed in the front of the block to attach the tape-chains when the frame is used at rear end of the tapes. A triangular space is cut out of the block, and in the sides adjacent are cut seats for the knife-edges *r* of the balance beam to rest in.

The balance-beam, shown in side view and projection, Plate 2, is brass, and has steel knife-edges *r* on which it rests, and knife-edges *s*, about which turn the stirrups of the steel hook to which is attached the front end of the tape-chain. On top of the upper short-arm of the beam is a small level vial in a case attached by adjusting screws to the beam. On the end of this short-arm is a screw on which works a counterpoise to balance the beam without the pea. The long-arm of the beam is divided so that the mark 5, which is the same distance from the knife-edges *r*, on which the beam rests, as are the knife-edges *s* about which the stirrups turn, shall indicate a tension equal to the weight of the pea, and twice that distance a tension twice the weight of the pea. The pea weighs 5 pounds and its mass is so distributed that the center of gravity lies in a vertical plane perpendicular to the face through the index point.

3. Two verniers.

Vernier, shown in vertical projection, side and end views, also vertical section and horizontal projection of the vernier block, Plate 3, consists of a clamp and frame similar to the frame of the tension-balance, with the addition of a hollow cast-block. This block is attached to a slow-motion screw for raising it under the tapes after they are stretched, and is guided by flanges sliding in grooves in two vertical arms fastened to the other brass block, which is capable of transverse motion. The hollow cast-block has on its upper face two metal graduated strips laid flat, with stops near the ends to hold the tapes close to the vernier. Verniers are marked 0 at the middle, and are set exactly opposite. The graduation extends 9 millimeters each way from the zeroes, and is divided into ten parts, so that the reading is to a tenth of a millimeter. In the grooves of the vertical arms slips a flange fastened to a bar carrying folding compass-sights, which enables the vernier zeroes to be brought at right angles to the base line. In the center of the head of vertical slow-motion screw is a small hook for attaching a plum-bob.

4. Tape clamps.

There are four clamps an inch long, made so as to permit the tape to be slipped in on one side and held by a bearing-plate pressed by two milled-head set-screws, giving a straight pull in aligning, and having a swivel hook at one end.

5. Tape chains.

There are four chains, about a meter long, made of No. 12 steel wire links about half an inch long.

6. Tape supports.

There are nine suspension supports, made of No. 12 wire, shaped like two sides of an isosceles triangle whose height is 3 and base 2 inches, with a ring turned at the apex and having an extended hook with flat bottom at the end of each leg; the support is flat—that is, wire is all in the same plane.

Dimensions of instruments and lumber are given in feet and parts of a foot, rather than in the metric system, to conform to the customary measure of makers and mills.

To measure the base, the line is cleared, and six stakes, 3 feet long, 2 inches square;

three pieces of plank, 1¼ inches thick, 2 inches wide, and 2 feet long; nine stakes 2 inches square, and of lengths somewhat to compensate irregularities of the ground line, are distributed over each tape length; stakes are all lined by transit. Beginning at the rear end of the tape, two stakes are driven about 3 feet back of the initial point of the base. On top is nailed a piece of the plank, which makes a table to clamp tension frames to, one on each side. Two stakes are next driven level with the first two stakes, but 2 inches to the right of the line, about 9 inches forward and back of the initial point of the base. On these is nailed a plank for clamping vernier. Along the line, at intervals of one-tenth the tape length, stakes are set, with nails driven in the rear face of the stake, the heads being a little lower than the points; the nails are kept about level by the eye. At the front end of the tape stakes are set for tables as at the rear end and in addition a table is set on line about three feet forward of the end of the tape and 2½ inches lower than the vernier table, for clamping the tension frames of the balance beams. Elevations are taken on the vernier and heads of nails with a level. An observer, a recorder, and one assistant at each end of the tapes, and nine men at intervals of one-tenth the tape length, place the tapes one on each side of the stakes supported by the suspension hooks hung on the nails. The assistants adjust the clamps near the tape ends, and hook on the chains, clamp the tension frames to the straining tables, one on each side, and by means of the chains attach the rear ends of the tapes to the frames and the front ends to the hooks on the balance beams, rest the beams on the knife-edges, and slip the pea on the beam and set it to the required pull; adjust the tension by the slow-motion screws of the frames till the beam is balanced and the level centered. The observers clamp a vernier to the table at each end of the tape. At the rear it is set by the plumb over the initial point, aligning by the compass sights, raised under the tapes by the elevating screws, and adjusted by the transverse screws till the tapes lie easily alongside the verniers. With pocket rule rear observer measures height of vernier above table. Observer at front end cries, "Ready! Read steel!" Both read the distance in millimeters on the tape from its zero to vernier zero and tenths of a millimeter on vernier, and have recorders make entry. Observer at rear end replies, "Read!" Observer at front end cries, "Read brass!" Both read as before, and observer at rear end replies, "Read!" Front observer cries, "Shift tapes forward!" and assistants by means of the slow-motion screws move the tapes bodily several centimeters along their length, the men at intermediate stakes being careful to keep supporting-hooks swinging free by tapping them lightly. Front observer again cries, "Ready!" and the program is repeated. The tapes are then shifted back beyond the initial reading, and readings taken again.

In the reduction the mean of all the readings for each tape is taken to obtain the distance between vernier zeroes.

For the next tape length the front observer calls out "Make ready!" assistant at front end lifts balance-beams and slips off the peas, both assistants unhook chains and unclamp tension-frames, men along the line lift tapes and suspension hooks, rear observer unclamps vernier and sends it forward by his recorder to front recorder, front observer *leaves his vernier clamped* and calls "Forward, march!" The remaining part of the base is measured in the same way, except that after moving forward the rear observer does not change the position of his vernier, unless he may have to alter the elevation by the elevating-screw. In reading and recording *forward* is counted from tape zero in the direction the base is measured. At the front end of the tape, *forward* readings are *plus* and *backward* readings are *minus*. At the rear end, *forward* readings are *minus* and *backward* readings are *plus*. The check on readings in the field is that the *first* reading at *front* end *minus second* reading at *front* end must be nearly equal (within half a millimeter) the *first* reading at *rear* end *minus second* reading at *rear* end, and must be of *opposite sign*; in other words, after the tapes are shifted the shift must show the same amount and of *opposite* sign at the two ends of the tape, otherwise the readings were wrong.

GENERAL FORMULAS DEVELOPED IN DETERMINING ABSOLUTE LENGTH OF STEEL TAPE, BASES, AND TEMPERATURE FROM TAPES USED SIDE BY SIDE.

Let $s_1 \ldots s_2 \ldots s_n$ = mean vernier readings, front end, steel tape.
$s'_1 \ldots s'_2 \ldots s'_n$ = mean vernier readings, rear end, steel tape.
L = length of tape at 60° F.
e = co efficient of expansion of steel tape.
$d_1 \ldots d_2 \ldots d_n$ = absolute distances between verniers.
$T_1 \ldots T_2 \ldots T_n$ = temperature, Fahrenheit, at time of measurement.

BASE MEASURING, RED RIVER SURVEY. FRONT END.

BASE MEASURING, RED RIVER SURVEY. REAR END.

Then, $L+e(T-60^\circ)L$=length of tape at time of measurement and $\Sigma d=B$ the length of base.

$$L+e(T_1-60^\circ)L+[(s_1+s'_1)+e(T_1-60^\circ)(s_1+s'_1)]=d_1$$

Hence,

$$L+e(T_1-60^\circ)L=d_1-[1+e(T_1-60^\circ)](s_1+s'_1)$$

Also,

$$L+e(T_2-60^\circ)L=d_2-[1+e(T_2-60^\circ)](s_2+s'_2)$$

. . . . . .

$$L+e(T_n-60^\circ)L=d_n-[1+e(T_n-60^\circ)](s_n+s'_n)$$

$$L=\frac{B-[1+e(T_1-60^\circ)](s_1+s'_1)-[1+e(T_2-60^\circ)](s_2+s'_2)\ldots.-[1+e(T_n-60^\circ)](s_n+s'_n)}{n+e[(T_1-60^\circ)+(T_2-60^\circ)\ldots.+(T_n-60^\circ)]}$$

But $e=0.000006+$ and $T-60^\circ$ has no digit higher than the tens place, and generally only in the units place; also, $s+s'$ has the first significant figure in second or third decimal place; hence the product, $e(T-60^\circ)(s+s')$, will have the first significant figure not higher than the *fifth or sixth decimal* place and may be neglected, and the formula becomes

$$L=\frac{B-(s_1+s'_1)-(s_2+s'_2)\ldots.-(s_n+s'_n)}{n+e(t_1+t_2\ldots.+t_n)}$$

where $T_1-60^\circ=t_1$, $T_2-60^\circ=t_2$, etc.

But correction for change in grade $c=\frac{\Sigma h^2}{2e}+\frac{\Sigma h^4}{se^3}$ *must be added to the length of the base*, where h is the difference in height of *adjacent supports and* e the *interval* between supports.

Hence,

$$L=\frac{B+\frac{\Sigma h^2}{2e}+\frac{\Sigma h^4}{se^3}-(s_1+s'_1)-(s_2+s'_2)\ldots.-(s_n+s'_n)}{n+e(t_1+t_2\ldots.+t_n)}$$

$$=\frac{B+\frac{\Sigma h^2}{2e}+\frac{\Sigma h^4}{se^3}-\Sigma(s+s')}{n+e\Sigma t}$$

When the length of the tape is known the length of the base is given by the following equation:

$$B=nL+e(t_1+t_2\ldots.+t_n)L-\frac{\Sigma h^2}{2e}-\frac{\Sigma h^4}{se^3}+(s_1+s'_1)+(s_2+s'_2)\ldots.+(s_n+s'_n)$$

$$=nL+eL\Sigma t-\frac{\Sigma h^2}{2e}-\frac{\Sigma h^4}{se^3}+\Sigma(s+s')$$

When brass and steel tapes are both used, the lengths being known at 60° F.,

Let $b_1\ldots.b_2\ldots.b_n$=mean vernier readings, front end, brass tape.
$b'_1\ldots.b'_2\ldots.b'_n$=mean vernier readings, rear end, brass tape.
L_1 =length of brass tape at 60° F.
e_1 =co-efficient of expansion of brass tape.

$$L_1+e_1(T_1-60^\circ)L_1+(b_1+b'_1)=d_1=L+e(T_1-60^\circ)L+(s_1+s'_1)$$

$$e_1t_1L_1-et_1L=L-L_1-(b_1+b'_1)+(s_1+s'_1)$$

$$t_1=\frac{L-L_1-(b_1+b'_1)+(s_1+s'_1)}{e_1L_1-eL}$$

$$\Sigma t=\frac{n(L-L_1)-\Sigma(b+b')+\Sigma(s+s')}{e_1L_1-eL}$$

When

$$L=L_1$$

$$\Sigma t=\frac{\Sigma(s+s')-\Sigma(b+b')}{(e_1-e)L}$$

To obtain the true lengths of the tapes, the base of the United States Coast and Geodetic Survey at Delta, La., was measured on three nights. The description was furnished this office in manuscript. This base was selected and measured by the United States Coast and Geodetic Survey by means of 6-meter contact slide-rods in 1878. Length of base between monuments is 2,716.6434 meters.

Southwest base is located in the southwest part of Delta, La., just across the Vicksburg, Shreveport and Pacific Railway track, and about 10 meters from the southeast side of the parish road. It is marked by a limestone monument 4 feet long, dressed to 14 by 14 inches at the top, with a one-fourth inch hole, having leaded into it a copper bolt with a cross cut on it. The monument was set in concrete. Elevation 32.837 meters above Cairo datum. There is no underground mark. A range-stone 3½ feet long, dressed to 6 by 6 inches at the top, with a one-fourth-inch copper bolt, marked, with a cross, let into it, stands 85.12 feet from southwest base in prolongation of the base line.

Northeast base is located three-fifths of a mile northeast of Delta, La., on a point formed by a bend in the river, and is nearly equi-distant from two negro cabins, the last on the point. The base is marked in every respect like southwest base, with the exception that the range stone and its underground mark are in line *between* the bases and 54.96 feet from northeast base.

The following shows the field record at front and rear end of the steel tape on the night of April 9, 1889, for the first half-dozen tape lengths:

DELTA BASE.

Observations for standardizing steel tape.

FRONT END.

Tape No.	Reading. + Forward.	Reading. —Backward.	Thermometer No. 2.	Time.	Mean reading.	Remarks.
	Mm.	*Mm.*	°	*P. M.*	*Mm.*	April 9, 1889.
1	67.1		66.1	8.22		
	4.6		68.0		+27.7	T. C. Thomas, observer; W. L. Polk, recorder.
	11.3		68.4			
2	39.1		66.8	8.40		
	32.0		66.9		+41.2	Thermometer No. 2. At 70 meters from rear end is U. S. Signal Service compared thermometer No. 791.
	52.5		66.5			
3	2.8		63.1	8.57		
	3.1		63.1		+ 7.7	
	17.1		62.5			
4		1.3	60.2	9.23		
	1.5		58.2		+ 0.6	
	1.5		58.1			
5	43.9		60.0	9.50		
	36.4		59.6		+35.4	
	25.9		59.3			
6	49.7		57.8	10.04		
	59.5		57.7		+58.8	
	67.2		57.7			

REAR END.

Tape No.	Reading. — Forward.	Reading. +Backward.	Thermometer No. 1.	Time.	Mean Reading.	Remarks.
	Mm.	*Mm.*	°	*P. M.*	*Mm.*	
1	19.3		68.0			
		42.0	67.8		+19.1	Vernier $2\frac{7}{10}$ inches above table.
		35.5	68.8			T. G. Rombauer, observer; C. L. Schermerhorn, recorder.
2	26.0		68.5			
	20.0		68.8		—38.6	Vernier 2½ inches above table.
	39.8		68.8			
3		8.8	64.3			
		8.7	64.3		+ 4.1	Vernier 2¾ inches above table.
	5.3		64.9			
4	14.1		63.3			
	14.1		62.1		—14.1	Vernier 2¾ inches above table.
	14.2		62.8			
5	9.3		61.0			
	1.8		60.9		— 0.8	Vernier 2¾ inches above table.
		8.7	60.8			
6	14.3		59.0			
	23.5		59.0		—22.8	Vernier 2¼ inches above table. Thermometer No. 1. At 30 meters from rear end is U. S. Signal Service compared thermometer No. 1522.
	30.7		58.9			

Table following gives the reduction from complete field record, of which preceding were a part. Themometer readings have been corrected from error sheet.

DELTA BASE.

APRIL 9, 1889.

Tape No.	Steel tape. Mean reading. S	S'	$S+S^*$ +	−	Thermometer. No. 1522.	No. 791.	Mean.	T-60°	Erase correction. Σh^2	Σh^4
1	+0.0277	+0.0194	0.0471	.....	67.6	66.8	67.2	+7.2	0.1121	0.0125
2	+0.0412	−0.0286	0.0126	.....	68.4	66.0	67.2	+7.2	0.2608	0.0681
3	+0.0077	+0.0041	0.0118	.....	64.1	62.2	63.1	+3.1	0.0342	0.0011
4	+0.0006	−0.0141	.....	0.0135	62.3	58.1	60.2	+0.2	0.2234	0.0497
5	+0.0354	−0.0008	0.0346	.....	60.5	58.9	59.7	−0.3	0.0346	0.0012
6	+0.0588	−0.0228	0.0360	.....	58.6	57.0	57.8	−2.2	0.4146	0.1722
7	−0.0056	−0.0022	.....	0.0078	60.4	60.3	60.3	+0.3	1.3187	1.7389
8	−0.0155	−0.0091	.....	0.0246	59.5	58.4	58.9	−1.1	0.0058	.....
9	+0.0689	−0.0392	0.0297	.....	59.7	59.3	59.5	−0.5	0.0065	.....
10	+0.0203	−0.0022	0.0181	.....	59.8	60.0	60.3	+0.3	0.0049	.....
11	+0.0272	−0.0105	0.0167	.....	60.3	59.5	59.9	−1.0	0.0061	.....
12	+0.0222	+0.0228	0.0450	.....	59.2	58.9	59.0	−1.0	0.0341	0.0011
13	−0.0449	+0.0074	.....	0.0375	59.1	58.0	58.5	−1.5	0.0077	0.0001
14	+0.0101	+0.0109	0.0210	.....	59.6	59.7	59.6	−0.4	0.0104	0.0001
15	+0.0090	+0.0095	0.0185	.....	59.9	60.3	60.1	+0.1	0.0139	0.0002
16	+0.0142	+0.0209	0.0349	.....	62.4	61.4	61.9	+1.9	0.0099	0.0001
17	+0.0146	−0.0103	0.0043	.....	61.7	61.8	61.7	+1.7	0.0043	.....
18	+0.0429	−0.0337	0.0092	.....	61.4	61.0	61.2	+1.2	0.0102	0.0001
19	+0.0475	−0.0138	0.0337	.....	60.7	59.9	60.3	+0.3	0.0937	.....
20	+0.0100	−0.0355	.....	0.0255	56.9	59.9	59.9	−0.1	0.0265	0.0007
21	+0.0168	−0.0061	0.0107	.....	60.1	59.5	59.3	−0.7	0.0037	.....
22	+0.0419	−0.0419	.....	.....	58.3	58.5	58.4	−1.6	0.0203	0.0001
23	+0.0261	−0.0066	0.0195	.....	59.3	59.1	59.2	−0.8	0.0708	0.0050
24	+0.0518	−0.0187	0.0331	.....	58.5	60.0	59.2	−0.8	0.0354	0.0012
25	−0.0146	−0.0104	.....	0.0250	58.2	59.1	58.6	−1.4	0.0038	.....
26	−0.0025	−0.0070	.....	0.0095	61.2	62.4	61.8	+1.8	0.0043	.....
27	−0.0322	−0.0234	.....	0.0556	59.2	59.1	59.1	−0.9	0.3911	0.1529
			0.4365	0.1990				+11.9	3.0720	2.3056
			+0.2375							

The following are equations for length of cape from foregoing and from observations made in the same manner on the nights of April 10 and 11:

$$L = \frac{2716.6434 - 0.2375 + \frac{3.0720}{20.12} + \frac{2.3056}{3144.56}}{27 + 0.000006 \times 11.9}$$

$$L = \frac{2716.6434 - 0.1601 + \frac{3.0073}{20.12} + \frac{2.1555}{8144.56}}{27 + 0.000006 \times 138.7}$$

$$L = \frac{2716.6434 - 0.0707 + \frac{3.0819}{20.12} + \frac{2.1941}{8144.56}}{27 + 0.000006 \times 288.3}$$

Whence,

$L = 100.61301$ meters.
$L = 100.61295$ meters.
$L = 100.61304$ meters.
Mean $L = 100.61300$ meters.

It will be noticed that the mean temperature above 60° Fah., on the several nights was 0.4°, 5.1°, 10.7°, and that the length of the tape as determined when the temperature differed but little from the standard, 60° Fah., is only 0.000015 meters different from the mean length obtained from the other two measurements, and while it may be accidental, it indicates that there is no considerable error in the assumed coefficient of expansion for the steel tape. To make the tape length as certain as practicable, it is proposed to measure another base of the U. S. Coast and Geodetic Survey near the mouth of Red River, and then return immediately to remeasure the Delta base.

The following results were obtained by comparing brass and steel tape stretched side by side under 16 pounds tension and supported as in measuring a base. Omitted readings rejected in the field.

Comparison brass and steel tapes.

METRIC SCALE.

Date.	Tape No.	Steel tape.			Brass tape.			Thermometer.			T—60° F.
		Reading.		$s+s'$	Reading.		$b+b'$	No. 1522.	No. 791	Mean.	
		s	s'	—	b	b'	+				
1889.											
May 8	5	—0.0127	—0.0048	0.0185	+0.0063	—0.0051	0.0012	75.6	76.1	75.8	+15.8
	6	—0.0132	—0.0848	0.0180	+0.0070	—0.0051	0.0019	74.8	75.3	75.0	+15.0
	7	—0.0123	—0.0848	0.0171	+0.0084	—0.0051	0.0033	72.6	73.1	72.8	+12.8
	8	—0.0119	—0.0048	0.0167	+0.0090	—0.0051	0.0039	72.2	72.0	72.1	+12.1
	9	—0.0104	—0.0048	0.0152	+0.0114	—0.0051	0.0063	71.4	70.1	70.7	+10.7
	10	—0.0101	—0.0048	0.0149	+0.0120	—0.0051	0.0069	70.9	68.1	69.5	+ 9.5
	12	—0.0096	—0.0047	0.0143	+0.0125	—0.0046	0.0079	69.6	68.9	69.2	+ 9.2
May 25*	8	+0.0057	—0.0233	0.0176	+0.0795	—0.0892	0.0097	78.5	79.6	79.0	+19.0
	9	+0.0157	—0.0336	0.0179	+0.0879	—0.0906	0.0027	78.5	79.2	78.8	+18.8
	10	+0.0088	—0.0264	0.0176	+0.0812	—0.0825	0.0013	78.2	79.3	78.7	+18.7
	11	—0.0017	—0.0160	0.0177	+0.0712	—0.0747	0.0035	78.5	79.3	78.9	+18.9
	12	—0.0140	—0.0040	0.0180	+0.0637	—0.0670	0.0033	78.3	79.2	78.7	+18.7
	13	—0.0235	+0.0058	0.0177	+0.0575	—0.0605	0.0030	78.3	79.2	78.7	+18.7
	14	—0.0312	+0.0137	0.0175	+0.0523	—0.0555	0.0032	78.2	79.1	78.6	+18.6
	15	—0.0474	+0.0296	0.0178	+0.0449	—0.0464	0.0015	78.0	79.1	78.5	+18.5
May 27, a. m.	2	—0.0811	+0.0303	0.0508	—0.0071	—0.0290	—0.0361	85.3	84.1	84.7	+24.7
	3	—0.0811	+0.0303	0.0508	—0.0071	—0.0288	—0.0359	87.2	83.1	85.1	+25.1
	4	—0.0825	+0.0303	0.0522	—0.0078	—0.0288	—0.0366	87.7	81.1	84.4	+24.4
	5	—0.0826	+0.0303	0.0523	—0.0083	—0.0288	—0.0371	89.6	80.3	84.9	+24.9
	6	—0.0827	+0.0303	0.0524	—0.0083	—0.0288	—0.0371	90.7	81.1	85.9	+25.9
	7	—0.0831	+0.0303	0.0528	—0.0090	—0.0288	—0.0378	89.0	81.9	85.4	+25.4
	8	—0.0821	+0.0305	0.0516	—0.0091	—0.0287	—0.0378	88.0	83.0	85.5	+25.5
	9	—0.0832	+0.0303	0.0529	—0.0090	—0.0288	—0.0378	87.8	83.2	85.5	+25.5
	10	—0.0835	+0.0304	0.0531	—0.0096	—0.0288	—0.0384	90.4	84.2	87.3	+27.3
	11	—0.0839	+0.0304	0.0535	—0.0099	—0.0288	—0.0387	91.5	85.4	88.4	+28.4
May 27, p. m.*	1	—0.0829	+0.0304	0.0525	—0.0099	—0.0288	—0.0387	88.3	85.2	86.7	+26.7
	2	—0.0715	+0.0178	0.0537	—0.0055	—0.0367	—0.0422	89.2	84.9	87.0	+27.0
	3	—0.0715	+0.0175	0.0540	—0.0045	—0.0367	—0.0412	88.5	85.1	86.8	+26.8
	4	—0.0604	+0.0060	0.0544	+0.0031	—0.0446	—0.0415	88.5	86.2	87.3	+27.3
	5	—0.0680	+0.0141	0.0539	—0.0060	—0.0332	—0.0392	89.0	87.1	88.0	+28.0
	6	—0.0761	+0.0218	0.0543	—0.0181	—0.0215	—0.0396	91.5	85.1	88.3	+28.3
	7	—0.0795	+0.0247	0.0548	—0.0255	—0.0191	—0.0446	90.7	84.4	87.5	+27.5
	8	—0.0807	+0.0247	0.0560	—0.0255	—0.0191	—0.0446	92.1	85.3	88.7	+28.7
	9	—0.0825	+0.0283	0.0542	—0.0421	+0.0004	—0.0417	89.7	86.0	87.8	+27.8
	10	—0.0880	+0.0337	0.0543	—0.0452	+0.0045	—0.0407	89.2	85.1	87.1	+27.1
	11	—0.0935	+0.0387	0.0548	—0.0509	+0.0094	—0.0415	87.5	84.3	85.9	+25.9
	12	—0.0982	+0.0432	0.0550	—0.0579	+0.0107	—0.0472	87.0	83.4	85.2	+25.2
	13	—0.0842	+0.0287	0.0555	—0.0442	—0.0020	—0.0462	88.4	85.3	86.8	+26.8

* Tapes shifted forward and back in this set.

The result of each observation being written in the general form

$$t=\frac{L-L_1-(b+b^1)+(s+s^1)}{e_1\ L_1-eL.}, \text{ or } t\,(L_1\,e_1-Le)=L-L_1+[(s+s^1)-(b+b^1)]$$

putting $y=(s+s^1)-(b+b^1)$ $\quad x=t$ $\quad a=L_1\,e_1-L\,e$ $\quad c=L-L_1$

the equation becomes $ax=c+y$.

When x and y are taken as the mean of all the observations

$$c=ax_0-y_0$$

and taking the difference between the mean and each observation

$$a\,(x-x_0)-(y-y_0)=0$$

By multiplying through by $(x-x_0)$, that is, giving each observation weight according to its range in temperature,

$$a\,(x-x_0)^2-(x-x_0)\,(y-y_0)=0$$

Summing the results of all observations,

$$a\,\Sigma\,(x-x_0)^2-\Sigma\,(x-x_0)\,(y-y_0)=0$$

$$a=\frac{\Sigma\,(x-x_0)\,(y-y_0)}{\Sigma\,(x-x_0)^2}$$

In the thirty-eight observations, $y_0 = -0.01516$, $x_0 = 22°.24$, from the reduction shown in the following table,

$$a = \frac{0.61176}{1309.62} = +0.0004671$$

the change in relative lengths of tapes for each degree alteration of temperature. Hence

$$e_1 - e = 0.000004645 \qquad e = 22.24 \times 0.0004671 + 0.01516 = 0.02554$$

At 0° F. $L = L_1 + 0.05358$; at 60° F. $L = L_1 + 0.02554$; at 82°.2 F. $L = L_1 + 0.01516$; at 114°.7 F. $L = L_1$.

Computation: Comparison of brass and steel tapes.

METRIC SCALES.

Tape No.	$\frac{(s+s')-(b+b')}{y}$	$y - y_0$	$x - x_0$	$(x-x_0)^2$	$(x-x_0)(y-y_0)$ −	$(x-x_0)(y-y_0)$ +
5	—0.0197	—0.0045	— 6.4	40.96	.....	0.02880
6	—0.0199	—0.0047	— 7.2	51.84	.....	0.03380
7	—0.0204	—0.0052	— 9.4	88.36	.....	0.04888
8	—0.0206	—0.0054	—10.1	102.01	.....	0.05454
9	—0.0215	—0.0063	—11.5	132.25	.....	0.07245
10	—0.0218	—0.0066	—12.7	161.29	.....	0.08382
12	—0.0222	—0.0070	—13.0	169.00	.....	0.09100
8	—0.0169	—0.0017	+ 3.2	10.24	.....	0.00544
9	—0.0152	.....	— 3.4	11.56	.....	.....
10	—0.0163	—0.0012	— 3.5	12.25	.....	0.00420
11	—0.0142	+0.0010	— 3.3	10.89	0.00330	.....
12	—0.0147	+0.0005	— 3.5	12.25	0.00175	.....
13	—0.0147	+0.0005	— 3.5	12.25	0.00175	.....
14	—0.0143	+0.0009	— 3.6	12.96	0.00324	.....
15	—0.0163	—0.0011	— 3.7	13.69	.....	0.00407
2	—0.0147	+0.0005	+ 2.5	6.25	.....	0.00125
3	—0.0149	+0.0003	+ 2.9	8.41	.....	0.00087
4	—0.0156	—0.0004	+ 2.2	4.84	0.00088	.....
5	—0.0152	.....	+ 2.7	7.29	.....	.....
6	—0.0153	—0.0001	+ 3.7	13.69	0.00037	.....
7	—0.0150	+0.0002	+ 3.2	10.24	.....	0.00064
8	—0.0138	+0.0014	+ 3.3	10.89	.....	0.00462
9	—0.0151	+0.0001	+ 3.3	10.89	.....	0.00033
10	—0.0147	+0.0005	+ 5.1	26.01	.....	0.00255
11	—0.0148	+0.0004	+ 6.2	38.44	.....	0.00248
1	—0.0138	+0.0014	+ 4.5	20.25	.....	0.00630
2	—0.0115	+0.0037	+ 4.8	23.04	.....	0.01776
3	—0.0128	+0.0024	+ 4.6	21.16	.....	0.01104
4	—0.0129	+0.0023	+ 5.1	26.01	.....	0.01173
5	—0.0147	+0.0005	+ 5.8	33.64	.....	0.00290
6	—0.0147	+0.0005	+ 6.1	37.21	.....	0.00305
7	—0.0102	+0.0050	+ 5.3	28.09	.....	0.02650
8	—0.0114	+0.0038	+ 6.5	42.25	.....	0.02470
9	—0.0125	+0.0027	+ 5.6	31.36	.....	0.01512
10	—0.0136	+0.0016	+ 4.9	24.01	.....	0.00784
11	—0.0133	+0.0019	+ 3.7	13.69	.....	0.00703
12	—0.0078	+0.0074	+ 3.0	9.00	.....	0.02220
13	—0.0093	+0.0059	+ 4.6	21.16	.....	0.02714
				1309.62	0.01129	0.62305
					+0.61176	

38)—0.5763

—0.01516

TRIANGULATION.

The triangulation has been carried by a system of 237 single triangles with sides varying from 400 to 4,000 meters and averaging 800 meters, divided into six stretches by seven bases, two of whose lengths were obtained by measurement with the base apparatus and the others by measurement with a small compared tape, and the azimuths determined by observation of a circumpolar star at elongation, the latitude being scaled from a map or obtained from a single observation of a circumpolar star at culmination. Angles of the triangles were measured by an ordinary 6-inch limb transit with plate divided to 30 minutes and reading to minutes by two verniers. The total reading, after repeated pointings at adjacent stations with plate and limb alternately clamped, was divided by the number of repetitions. Except in a few cases

triangles closed with an error less than 20 seconds, and horizon less than 30 seconds.

Azimuth and latitude were observed with an 8-inch transit, reading by verniers to 10 seconds, and vertical circle reading to 20 seconds, having a level on the telescope. Azimuth observations were made by pointing at mark, then at star at elongation, and back to mark. Latitude was obtained from altitude of the star at culmination above the horizon indicated by the telescope level.

The following table shows comparison on bases. The mean ratios of discrepancy in lengths through 58 triangles is 1 in 9,000, and in azimuth the mean discrepancy between observed and carried azimuth is $\pm 1' 28''$.

Check on base-lines.

METRIC SCALE.

Base.	Number of triangles.	Length.		Ratio of discrepancy.	Azimuth.		Discrepancy.	Observed latitude.
		Measured.	Calculated.		Observed.	Carried and corrected for convergence.		
					° ′ ″	° ′ ″	′ ″	° ′ ″
Shreveport	------	704.34	------	------	96 45 49	------	------	------
Caspiana	67	518.43	518.53	1 : 5184	178 05 46	178 08 01	2 15	------
Coushatta	76	609.90	609.94	1 : 15247	234 46 55	234 45 00	1 55	------
High-Die	73	640.33	640.25	1 : 8004	127 52 29	127 52 08	21	31 40 50
Colfax	61	518.26	518.67	1 : 1264	160 07 59	160 09 03	1 14	31 29 50
Alexandria	47	955.68	955.78	1 : 9556	261 48 21	261 46 58	1 23	31 17 47
Grand Bend	23	609.81	609.85	1 : 15245	239 34 34	239 36 16	1 42	31 12 33

The discrepancies in carried and observed azimuth seem astonishingly large when compared with discrepancies in lengths of bases, but the adjustment of a single system of triangles in which each angle of a triangle is taken to be equally in error may leave greater uncompensated error in the azimuths than in the sides, on account of cases where the assumption is false. For, while the sum of the errors in three angles after adjustment is zero, the error in one angle or the sum of the error in two angles used in carrying the azimuth is not zero, but the difference of the errors in the two functions used in calculating the sides may be zero. No distribution of the error in lengths has been made through the sides, since the error, except in one stretch, does not enter in the length as given to the tenths place in the table. A correction of half the discrepancy in azimuth has been applied to the sides in the last half of the triangles of the stretch in which the discrepancy accumulated. Lengths of bases and sides are at their own elevation, and the triangles have been treated as plane. Elevations were obtained by checked levels with a wye level connecting stations and precise bench-marks. Stations on the right of the system are designated by even and on the left by odd numbers continuously from Shreveport down the river.

HYPSOMETRY.

The comparative elevation of points from Delta, La., to Grand Bend, La., via Shreveport, has been ascertained by the method of precise leveling lately practiced on Mississippi River surveys. In brief, while instrumental errors (tables *a*, *b*, *c*) have been determined and correction applied, every endeavor has been made to insure their entering the observation as the least factor possible. Each stretch has been duplicated in opposite direction by the same observer, and, as far as possible, under like favorable conditions. The instrument was shaded; work stopped during midday, except when cloudy; back and foresights equal, and not over 100 meters; readings taken with bubble at center, and the discrepancy of accepted results between runs in opposite directions was almost invariably less than 5 millimeters $\sqrt{\text{dist.}}$ in kilometers, the distance being counted *between benches*, and not the distance run both ways; nor were the runs made short to keep the ordinate of error close to the origin in the curve of allowable error.

Table 2 gives the results of observations between temporary bench-marks, they having been connected as a continuous line and the precise bench-marks connected as side lines. Descriptions and elevations of precise bench-marks are given in table 3, and sketches of location shown in plates 15 to 26 inclusive.

From Fulton, Ark., to Shreveport, La., elevations were obtained by using a wye level, as practiced on Missouri River surveys. This work having been done in the winter of 1886 and 1887, permanent marks have been established and over some reaches check levels run. Table 4 gives descriptions and elevations of bench-marks

and plates 10 to 12 show sketches of location. That part of the river from Shreveport to Caspiana was surveyed in 1885, and precise bench-marks have now been placed along the stretch, and elevations of river-section reference points obtained by checked connection thereto with wye level. From Caspiana to Grand Bend, elevations of triangulation stations and river section reference points were obtained by checked wye level connections to precise bench-marks; the two lines checked within 0·05 meter. Elevations of the former have been given in Table 1 of triangulation results, and of the latter in Table 5. In this last stretch of river there is scarcely any place where the distances between two benches of one form or another exceeds one kilometer.

Cross-sections on the line of Vicksburg, Shreveport and Pacific Railroad of streams tributary to Red River are shown by plates 13 and 14. A profile of both bank lines of the river, high and low-water line, outlets, tributaries, and cross-sections will be prepared.

TOPOGRAPHY.

The position of river banks, lakes, sloughs, bayous, woods, fields, houses, property lines, and principal contour points has been determined over an area about 700 meters wide on each side of the river, and the larger tributaries have been traced about 3,000 meters above their entrance into the river. At intervals of about 8 kilometers permanent reference sections were established with two points on each bank marked by cement-filled vitrified pipe. Those nearest the banks were set about 50 meters back and the others about 700 meters back. These points were all located instrumentally and will serve to measure changes which may take place in the banks and sections.

Between Fulton and Shreveport monuments have been set as reference for topographical work done in 1886–'87. Table 6 gives description of location and their elevation where it was obtained, and plates 4 to 9 show location.

All work was done by transit and stadia method. Azimuth generally checked on the triangulation within 2 minutes in a run of 8 kilometers, and elevations within 0.2 meters. Sheets were plotted in pencil to check the field work as it progressed, and 14 sheets, 26 by 34 inches, showing river from Fulton, Ark., to Gilmer, La., have been finished in pencil in the office on a scale of 1:10,000, from which charts may be published on completion of the survey.

HYDROGRAPHY.

Sections were located by instrument about 400 meters apart and soundings spaced by time. Channel soundings between sections were spaced by time and located on sketches by estimated distance from either bank. All soundings are reduced to what they would be if the gauge at Shreveport had read 10 feet continuously while the soundings were made. This was done in the following manner: It was assumed that the rate of progress of a change of stage was uniform between two consecutive gauges. The time interval between gauges was obtained by noting the time of reversion at each gauge; *i. e.*, the beginning or end of a rise or fall. The mean of all the time intervals was taken as the interval, and the mean of all the readings at each gauge at each reversion as the corresponding gauge reading. The ratios of corresponding gauge readings at consecutive gauges gave gauge relation. These "time intervals," "corresponding gauge readings," and "gauge relations" were determined from a number of observations with the river as near 10 feet at Shreveport as practicable, because, while quite true for the stage for which they are determined, they become wholly wrong for a greatly different stage. It was found that, the gauge reading at Fulton being 6.0, the gauge at Garland, 1 day 5½ hours later, read 6.2; the gauge at Collin's Bluff, 1 day and 15 hours after the Garland gauge reading, was 7.7; the gauge at Shreveport, 4 days and 4 hours later, read 10.0; the Coushatta gauge, 5 days and 15 hours later, read 6.8; the Alexandria gauge, 3 days and 9 hours later, read 4.9; giving a total of 15 days 15½ hours for a change of stage to travel from Fulton to Alexandria when the river is about 10 feet on the Shreveport gauge. Also a change at Garland is 1.03 times the change at Fulton; at Collin's Bluff 1.24 times the change at Garland; at Shreveport 1.29 times the change at Collin's Bluff; at Coushatta 0.68 times the change at Shreveport; and at Alexandria 0.72 times the change at Coushatta.

The distance from two gauges and the time of sounding being known, correction to reduce the soundings could be found. The time interval to the sounding station being proportional to the time interval between the gauges above and below, as distance to sounding station is to total distance between gauges, the time of sounding plus or minus this quantity gave time of gauge reading corresponding to the existing stage. The difference between gauge reading at that time and gauge reading corresponding to 10 feet at Shreveport multiplied by the ratio of distance of the sounding to distance between gauges multiplied by the gauge relation, gave correction.

In the office this correction was obtained graphically by constructing to scale the gauge above and below the point of sounding and connecting by a straight line the reading on each corresponding to 10 feet at Shreveport.

Then from the time interval the time of gauge reading corresponding to the existing stage was read off the horizontal scale opposite the point of sounding. The gauge readings at that time, as shown by their records, were connected by a straight line and the distance between the lines thus drawn measured on the ordinate at point of sounding gave the correction.

Gauge has been observed at Alexandria since 1871, at Coushatta since August 1, 1889, at Shreveport since 1886, while until the recent establishment of gauges at Fulton and Garland the reading was quite irregular, and the record at Collin's Bluff covers a very short period. Table 7 gives elevations of zeros of gauges above Cairo datum. For a thorough study of the relation of stage over the varying reaches of the river it would be necessary to establish three gauges near Collin's Bluff, one in Sulphur River, one in the main river above, and one below the entrance of Sulphur River. These would also indicate the characteristics of the river above the raft region. A gauge at Gilmer above Cottonwood Bayou, the principal outlet in the raft region, and one at Hurricane Bluff below would serve to determine the changed condition where the water is unconfined. Again, about Long Branch, below Tone's Bayou, a gauge would be needed to measure the depletion; one at Grand Ecore, where the waters come together; one at St. Maurice, midway of this basin; and one at Colfax, where the escape waters return from Cane River. Others would be needed on that part of the river which has not yet been passed over by the survey, but their proper location can be chosen as the work progresses.

Red River, on account of its varying character, flowing as it does over every kind of bottom, from hard rock to soft mud, between banks of endless degrees of cohesion, or over banks of almost any height and through basins of every width, having outlets and inlets, having slopes from very flat to very steep, banks cleared and banks wooded, reaches leveed and reaches unleveed, oscillations of every magnitude, sand-bars, pools, and shallows, presents all conditions for the solution of every problem pertaining to improvement of a silt-bearing river. Large enough to give sufficient supply of water for any method of improvement, it is not so large as to make the cost of any plan inordinately great and yet bearing commerce on its bosom which would justify any expenditure that might be necessary.

Nothing, however, is to be gained now by attempting to draw conclusions from data at hand, since their relation must be affected largely by physical conditions yet to be ascertained. For instance, the relation of velocity to slope and section is too closely intermingled in discharge to permit analogies to be drawn from like appearances when either factor is unknown. Any investigation of so complex a problem, with many qualities indeterminate, must inevitably lead to confounding coincidence with cause and effect, and the ultimate failure of plans based thereon.

Detailed estimates.

PLANT.

Purchase or construction of flat-boats with steam capstans or hoisting engines and cranes or shears, for low-water service of chopping parties	$6,000
Purchase of snag-boat *Breck* from improvement of Red River, above Fulton, Ark., when that work is finished	3,000
Purchase or construction of pile-driver	3,000
Purchase or construction of dredge dump-scows	3,000
Purchase or construction of small steamer for towing, general service, current measurements, etc	5,000
Purchase of skiffs, tools, rigging, and outfit	3,500

CARE OF PLANT.

Wages, subsistence, and supplies for fleet	3,500
Regular and extraordinary repairs	3,000

OPERATION OF PLANT.

Wages, subsistence, explosives, and material for chopping parties	8,000
Continuing work on Cypress Bayou and the lakes between Shreveport and Jefferson	10,000
Expenses of snag-boat *Howell*	18,000
Expenses of snag-boat *Florence*	12,000
Expenses of snag-boats *Wagner* and *Meigs*	6,000
Expenses of snag-boat *Breck*	4,000
Expenses of general-service steamer	4,000
Expenses of dredge *Lone Star*	5,000

CONSTRUCTION.

Widening, deepening, and straightening the channel through the Falls and building dike at Alexandria		$22,500
Repairing and enlarging the State levees by joining with the State engineers and levee boards, for the purpose of confining the waters of Red River to its adopted channel, thereby improving and giving ease and safety to the navigation of the river. Cubic yards to be built by the United States, as follows:		
Caddo district, above Shreveport	50,000	
Caddo district, below Shreveport	270,000	
Bossier district, below Shreveport	300,000	
Bossier district, above Shreveport	30,000	
Rapides district, from Alexandria to Avoyelles Prairie	140,000	
Total, 790,000 cubic yards		158,000
Closing outlets now depleting the river and injuring its navigation:		
Dooley's and Red Bayou		4,000
Sale and Murphey Canal		5,000
Cottonwood Bayou		7,000
Tone's Bayou		20,000
Choctaw Bayou		5,000
Draining impounded water from Choctaw Bayou by canal to Bayou Des Glaizes or otherwise		10,000

SURVEYS.

Cypress Bayou and the lakes between Shreveport and Jefferson, to determine the feasibility of slackwater navigation	12,000
Completing survey of Red River from Fulton to the Atchafalaya, according to approved project	125,000

ADMIDISTRATION AND INSPECTION.

Office rent, pay of clerks, stationery, mileage, and contingencies	4,500
Pay of assistant engineers and inspectors, and traveling expenses	5,000
	475,000

The amounts expended during the fiscal year ending June 30, 1890, were as follows:

For general improvement, repairs, care of plant, etc. (including liabilities $15.14)	$23,751.56
For Cypress Bayou, etc. (including liabilities $1.07)	2,918.73
For Bayon Dorcheat	1,999.16
For the survey (including liabilities $3.81)	20,881.32
Total	49,550.77

Money statement.

July 1, 1889, amount available		$62,767.08
July 1, 1890, amount expended during fiscal year, exclusive of liabilities outstanding July 1,1889	$49,530.75	
July 1, 1890, outstanding liabilities	20.02	
		49,550.77
July 1, 1890, balance available		13,216.31
Amount appropriated by act of September 19, 1890		100,000.00
Amount available for fiscal year ending June 30, 1891		113,216.31
Amount that can be profitably expended in fiscal year ending June 30, 1892 Submitted in compliance with requirements of sections 2 of river and harbor acts of 1866 and 1867.		475,000.00

COMMERCIAL STATISTICS.

There was no time during the past fiscal year that a steam-boat drawing 2 feet of water could not navigate Red River from Shreveport to the month, a distance of 320 miles. No definite statistics could be obtained regarding the river from Shreveport

up. The business of that portion of river was estimated to be about the same as that of the previous year.

The following steam-boats were engaged in the Red River trade during the past fiscal year:

Name.	Registered tonnage.	Draft.		Round trips.
		Light.	Loaded.	
Between New Orleans and Shreveport:		*Ft. In.*	*Ft. In.*	
Dacotah	956.98	2 0	5 0	10
Danube	250.32	1 8	4 0	10
Garland	261.42	1 4	5 0	23
Hallette	196.8	1 4	4 2	21
John D. Scully	285.7	1 8	4 2	14
Valley Queen	410.83	2 2	7 0	17
E. B. Wheelock		1 6	5 0	1
Between Shreveport and Alexandria:				
E. B. Wheelock		1 6	5 0	17
C. E. Satterlee		1 6	5 6	33

	1888–'89.	1889–'90.
Freights by river:	*Tons.*	*Tons.*
Cotton	12,593	18,838
Cotton seed	11,975	14,140
Hides and skins	97	35
Live stock	32	.....
Lumber	.....	4,519
Staves	.....	58
Stone	4,600	.....
Sundries	373	136
Total down freights	29,670	37,726
Return freights	19,780	28,650
Total	49,450	66,376
Value	$5,370,000	$6,820,310

The increase in freights over the previous year is due to the additional traffic of the local line of boats between Shreveport and Alexandria, and also to the good navigation maintained at the mouth of the river the greater part of the low-water season.

As near as can be estimated, the output of logs during a season of bank full stage of the river will net not less than 16,000,000 feet of lumber, which is not included in the above freights.

Red River is crossed by the St. Louis, Iron Mountain and Southern Railway at Fulton, Ark., by the St. Louis, Arkansas, and Texas Railway (Cotton Belt Route) at Garland Ark., and by the Vicksburg, Shreveport, and Pacific Railroad and a branch of the "Cotton Belt Route" at Shreveport. Two companies have applied for charters for bridges at Alexandria. The Texas and Pacific Railway, running nearly parallel to the river touches at Alexandria, Shreveport, and other points, and the Morgan's Louisiana, and Texas Railroad (Southern Pacific) has a branch running to Alexandria. All these lines divert a large percentage of the commerce. Over 13,000 bales of cotton were shipped by rail from Alexandria during the past season. The following compilation of receipts and shipments of cotton at Shreveport will be of interest.

	1888–'89.	1889–'90.
Sources of receipts.	*Bales.*	*Bales.*
By rail	30,331	25,476
By wagon	35,450	40,026
By river	12,368	8,897
Warehouse receipts	78,143	74,402
Shipments:		
By Texas and Pacific Railway	20,582	23,690
By Vicksburg, Shreveport and Pacific Railroad	24,029	20,813
By Shreveport and Houston Railroad	494	12,529
By St. Louis, Arkansas and Texas Railway	24,123	8,820
By river to New Orleans	8,956	8,412
Total	78,184	74,264

Cypress Bayou and the lakes were reported navigable the entire year. Two steamers made 33 round trips between Jefferson and Shreveport. The principal traffic was upstream freights of merchandise from New Orleans, which was transferred to the Cypress Bayou boats at Shreveport. No record of the commerce of the bayou was kept by the board of trade at Jefferson, and nothing of a very definite nature regarding it could be obtained at Shreveport.

Mr. W. T. Atkins, cashier of the national bank of Jefferson, reported the difference between rates by rail and water as follows:

"From July, 1889, to July, 1890, the up freights in general merchandise and supplies cost about $76,800 at rate of 30 cents per 100 pounds. Railroad rates would have been, were it not for the competition offered by the two local packets, $163,500."

In the past year a fine blast furnace was built on the bayou at Jefferson, and car-wheel works and a steel plant are to be put up during the coming year. The supplies for all of these and a large percentage of their products will be transported by river. The daily supply of material the present furnace requires is as follows: 120 tons of ore, 30 tons of limestone, 5,000 bushels of charcoal, 150 cords of wood, all of which require water transportation.

The following steam-boats plied between Shreveport and Jefferson during the past fiscal year:

Name.	Registered tonnage.	Draught.				Round trips.
		Light.		Loaded.		
		Ft.	In.	Ft.	In.	
New Haven	92.64	1	8	3	6	14
Friendly	67.76	1	0	3	6	19

Freights for 1889–'90:	Tons.
Cotton	200
Cotton seed	25
Return freights	3,300
Total tonnage	3,525
Total value	$304,325

A large number of logs were rafted out of the bayou, but the estimated number was so exaggerated that it is omitted.

A branch line of the Texas and Pacific Railway runs to Texarkana, thence to Arkadelphia, touching at Jefferson, Tex., on Cypress Bayou. Both the St. Louis, Arkansas and Texas and St. Louis, Iron Mountain and Southern Railways meet and converge at Texarkana, Texas and Arkansas. The Missouri, Kansas and Texas Railroad also has a branch line to Jefferson.

There was no commerce in Dorcheat Bayou, and there has not been a steam-boat over the route in the last five years. A tap railroad from Minden to the Vicksburg, Shreveport and Pacific Railroad at Sibley (5 miles) carries all the freights, and it is estimated that this line transported 18,000 bales of cotton the past year. It is stated that the merchants of Minden, in consideration of freight rates granted by the railroad, have agreed to make all shipments that way.

TABLE 1.—*Tabulated results of the tertiary triangulation of Red River from Caspiana Landing, Louisiana, to Grand Bend, Louisiana.*

[Assistant Engineer T. C. Thomas, chief of party; Walter H. Polk, observer.]

[NOTE.—Elevations are referred to the Cairo Datum, and each elevation applies to the first of the As' standing opposite.]

Side.	Distance.	Azimuth.	Elevation.
	Meters.	° ′	Meters.
N.B.— S.B*	518.4	358 06	
S. B.— 63	573.3	64 55	
63— N. B	602.8	117 09	
N.B.— 66	781.1	358 06	
66— 63	718.5	225 16	51.39
63— 65	1,007.4	8 34	
65— 66	608.7	143 42	52.71

*Caspiana Landing base line.

TABLE 1.—*Tabulated results of the tertiary triangulation of Red River, etc.*—Cont'd.

Side.	Distance.	Azimuth.	Elevation.
	Meters.	° ′	*Meters.*
66— 68	746.8	4 32	
68— 65	490.3	238 48	52.27
65— 67	478.6	340 25	
67— 68	612.4	108 46	52.73
68— 70	699.4	332 49	
70— 67	498.5	214 29	51.95
70— 70*a*	794.7	285 38	
*a*70— 67	814.6	141 42	51.90
67— 69	957.9	285 29	
69— 70*a*	567.4	47 29	52.24
*a*70— 72	791.6	282 44	
72— 69	660.8	147 37	51.33
69— 71	1,124.1	279 10	
71— 72	845.5	63 23	52.12
72— 74	1,071.0	279 23	
74— 71	835.2	164 12	52.46
71— 73	972.5	308 08	
73— 74	574.7	69 18	51.23
74— 76	906.5	305 17	
76— 73	754.1	164 27	52.13
73— 75	1,080.9	310 30	
75— 76	620.2	87 44	42.09
76— 78	960.3	307 54	
78— 75	629.8	167 21	51.00
75— 77	752.4	301 07	
77— 78	554.2	65 58	52.14
78— 80	563.2	306 33	
80— 77	563.7	185 28	50.95
77— 79	802.8	331 27	
79— 80	460.5	108 13	51.43
80— 82	694.1	335 53	
82— 79	513.1	197 26	51.77
79— 81	829.1	332 19	
81— 82	591.9	114 24	51.85
82— 84	958.8	342 35	
84— 81	716.1	200 36	51.26
81— 83	1,211.5	312 21	
83— 84	1,156.6	97 14	52.12
84— 86	1,179.0	312 25	
86— 83	706.0	203 06	51.91
83— 85	981.6	325 04	
85— 86	853.3	100 29	52.15
86— 88	948.1	324 35	
88— 85	981.8	205 07	50.28
85— 87	648.8	338 16	
87— 88	529.9	88 25	51.51
88— 90	620.2	333 15	
90— 87	621.2	203 48	50.73
87— 89	828.2	333 27	
89— 90	644.3	105 32	51.05
90— 92	1,066.5	338 48	
92— 89	854.8	195 58	50.00
89— 91	1,037.6	338 58	
91— 92	625.1	103 34	50.28
92— 94	900.3	346 57	
94— 91	834.8	208 58	50.47
91— 93	1,087.6	350 08	
93— 94	682.2	120 00	51.17
94— 96	1,060.3	343 20	
96— 93	733.0	203 01	50.71
93— 95	1,135.0	344 26	
95— 96	724.5	125 19	50.82
96— 98	917.5	345 37	
98— 95	594.0	217 42	50.34
95— 97	403.8	319 32	
97— 98	646.2	75 25	50.45
98—100	637.5	304 13	
100— 97	530.5	190 40	50.11
97— 99	869.1	325 57	
99—100	617.7	108 47	50.51
100—102	857.6	13 23	
102— 99	1,008.3	230 58	50.34
99—101	1,168.0	337 34	
101—102	1,307.0	109 53	50.54
102—104	1,378.0	339 34	
104—101	1,129.7	221 27	49.72
101—103	1,[illegible]63.1	354 31	
103—104	982.4	105 12	49.76
104—106	1,207.7	336 26	

TABLE 1.—*Tabulated results of the tertiary triangulation of Red River, etc.*—Cont'd.

Side.	Distance.	Azimuth.	Elevation.
	Meters.	° ′	*Meters.*
106—103	949.9	202 50	50.49
103—105	1,321.4	328 51	
105—106	1,082.7	103 38	50.29
106—108	1,449.8	342 14	
108—105	1,279.9	208 27	48.98
105—107	1,563.9	346 48	
107—108	1,045.3	112 20	49.72
108—110	718.4	351 27	
110—107	915.3	249 59	48.89
107—109	1,254.2	20 34	
109—110	957.8	154 02	49.19
110—112	811.7	46 16	
112—109	1,049.7	286 36	48.93
109—111	921.4	17 38	
111—112	1,384.1	148 20	50.28
112—114	1,145.3	11 37	
114—111	959.1	273 22	49.91
111—113	1,146.3	11 30	
113—114	1,384.6	148 22	49.79
114—116	1,980.3	3 40	
116—113	1,167.6	226 56	49.11
113—115	1,477.7	352 54	
115—116	1,232.7	122 52	49.66
116—118	1,762.2	343 56	
118—115	1,161.6	208 08	48.72
115—117	1,461.8	332 55	
117—118	1,244.4	102 52	48.64
118—120	1,566.8	326 08	
120—117	1,078.7	198 22	48.80
117—119	1,915.4	329 14	
119—120	1,459.1	115 14	49.12
120—122	2,560.9	333 51	
122—119	1,687.4	186 30	47.44
119—121	1,290.6	305 22	
121—122	1,552.4	53 13	48.64
122—124	2,176.1	277 14	
124—121	1,511.9	142 44	47.41
121—123	1,626.4	287 38	
123—124	952.6	41 46	49.00
123—125	1,176.3	320 40	
125—124	1,394.6	98 13	49.12
124—126	1,178.6	318 58	
126—125	917.7	221 22	48.30
125—127	1,411.6	352 30	
127—126	1,063.2	131 58	47.30
126—128	1,409.9	359 10	
128—127	1,040.1	227 47	48.77
127—129	1,311.6	341 32	
129—128	1,305.2	114 41	48.78
128—130	2,220.2	333 42	
130—129	1,450.4	187 58	47.38
129—131	2,206.0	309 59	
131—130	1,806.4	89 02	47.06
130—132	1,528.7	303 48	
132—131	1,081.8	215 21	47.25
132—134	917.7	259 46	
134—131	770.8	158 55	47.69
131—133	744.1	290 19	
133—134	623.9	42 23	47.56
133—135	1,125.3	323 11	
135—134	1,180.1	111 51	45.74
134—136	785.4	324 18	
136—135	666.7	252 45	47.09
135—S. B.	391.8	7 19	
S. B—N. B.*	609.9	154 47	
N. B.—135	350.1	297 47	
N. B.—136	487.0	42 11	
136—S. B	617.1	288 01	
136—138	691.4	357 12	
138—135	1,073.6	214 10	47.04
135—137	1,256.0	341 56	
137—138	1,038.5	107 07	48.51
138—140	1,479.5	343 26	
140—137	1,250.3	207 09	46.60
137—139	981.0	324 48	
139—140	1,177.9	74 43	47.94
140—142	1,836.1	319 10	
142—139	1,701.4	177 56	45.86
139—141	1,725.7	332 29	

*Coushatta base line.

TABLE I.—*Tabulated results of the tertiary triangulation of Red River, etc.*,—Cont'd.

Side.	Distance.	Azimuth.	Elevation.
	Meters.	° ′	*Meters.*
141—142	1,041.0	76 26	46.35
142—144	912.1	319 46	
144—141	1,101.9	201 09	44.20
141—143	1,048.6	343 51	
143—144	689.6	88 17	44.78
144—146	1,109.0	325 37	
146—143	937.9	183 51	46.76
143—145	1,634.9	323 46	
145—146	1,098.1	110 25	45.90
146—148	1,576.3	332 18	
148—145	1,054.5	196 19	45.86
145—147	1,701.5	335 44	
147—148	1,132.1	118 26	47.64
148—150	1,645.1	347 08	
150—147	1,236.7	210 34	44.34
147—149	1,534.0	323 40	
149—150	1,547.3	96 21	46.44
150—152	2,143.7	329 23	
152—149	1,732.3	194 56	44.80
149—151	2,068.5	330 54	
151—152	1,458.5	95 15	46.91
152—154	1,454.1	313 21	
154—151	950.8	204 33	44.84
154—154*a*	1,634.6	276 47	
*a*154—151	1,620.8	130 44	44.61
151—153	2,263.6	257 17	
153—154*a*	1,838.9	32 12	45.85
153—155	1,607.9	304 22	
155—154*a*	2,396.5	74 18	46.57
*a*154—156	3,602.2	288 05	
156—155	1,671.0	160 55	45.75
155—157	1,627.8	258 29	
157—156	2,173.9	28 51	55.94
157—158	2,770.4	345 23	
158—156	1,912.7	113 57	44.39
156—159	3,172.2	254 35	
159—158	2,083.2	38 58	54.15
159—161	2,019.3	4 12	
161—158	1,227.0	108 44	44.30
158—160	1,834.9	326 12	
160—161	1,139.5	187 07	43.99
161—163	1,169.7	273 36	
163—160	1,682.5	51 04	44.10
160—162	2,793.5	263 44	
162—163	1,649.8	117 08	43.06
163—163*a*	1,674.0	253 25	
*a*163—162	1,238.8	6 20	43.01
*a*163—165	1,667.2	264 40	
165—162	2,269.1	52 21	52.64
162—164	1,423.8	291 06	
164—165	1,955.3	193 51	45.62
165—166	2,666.2	319 15	
166—164	2,211.6	93 09	42.79
164—167	2,191.9	230 52	
167—166	1,588.3	341 21	50.00
166—169	1,863.8	202 25	
169—167	1,238.2	79 51	43.06
167—168	1,760.6	308 30	
168—169	1,323.8	173 06	43.72
169—171	1,860.5	207 31	
171—168	1,559.0	73 02	44.10
168—170	1,542.1	308 11	
170—171	1,434.8	191 14	43.33
171—173	1,947.7	301 36	
173—170	1,976.5	78 43	43.96
170—172	1,707.9	336 39	
172—173	2,326.6	212 50	43.45
172—174	1,600.1	285 30	
174—173	2,399.0	173 17	44.34
173—175	3,324.5	320 30	
175—174	1,843.0	95 42	42.74
174—176	2,116.6	321 49	
176—175	1,571.5	199 32	41.99
176—177	2,485.5	288 48	
177—175	2,923.2	141 18	41.38
175—178	4,295.0	354 36	
178—177	2,448.5	215 30	58.01
177—179	1,928.6	329 17	
179—178	2,430.3	82 04	41.52
178—180	3,055.5	301 22	
180—179	1,935.9	174 01	42.54

TABLE 1.—*Tabulated results of the tertiary triangulation of Red River, etc.*—Cont'd.

Side.	Distance.	Azimuth.	Elevation.
	Meters.	° ′	*Meters.*
179—181	2,669.4	310 12	
181—180	1,847.9	83 43	41.07
180—182	2,662.5	311 25	
182—181	1,970.2	175 21	41.81
181—183	2,795.8	320 56	
183—182	1,615.5	97 22	41.41
182—184	2,714.1	323 38	
184—183	1,978.4	179 47	35.45
183—185	2,797.5	314 23	
185—184	1,992.2	89 22	39.35
184—186	2,732.3	351 19	
186—185	3,146.8	210 08	39.27
185—187	2,541.6	357 30	
187—186	1,700.7	83 51	38.68
186—188	1,441.7	337 48	
188—187	1,901.6	217 04	38.51
188—190	1,733.3	278 14	
190—187	1,854.8	102 08	39.38
187—189	1,704.0	292 28	
189—190	1,500.7	42 04	39.86
189—192	2,097.2	352 15	
192—190	1,608.9	126 48	39.17
190—191	2,369.1	271 11	
191—192	1,415.9	49 44	39.03
192—193	1,638.9	278 47	
193—191	1,284.2	155 10	38.38
191—194	1,916.1	9 33	
194—193	1,122.0	229 49	39.10
193—195	1,358.2	349 42	
195—194	1,258.8	119 07	53.85
195—196	1,319.1	37 58	
196—194	1,677.2	170 06	39.18
194—197	2,339.0	314 46	
197—196	1,372.3	89 48	38.31
196—198	1,899.7	312 47	
198—197	1,295.2	179 01	38.65
197—199	1,840.4	315 04	
199—198	1,277.8	90 21	38.30
198—200	1,927.7	322 31	
200—199	1,525.1	183 56	38.55
199—201	1,495.8	305 08	
201—200	1,483.0	63 33	37.26
201—N. B	1,037.9	7 11	
N. B—200	1,253.7	107 08	38.21
200—202	1,638.4	822 00	
202—N. B	941.1	191 37	37.17
202—S. B	873.2	232 44	
S. B—N. B*	640.3	127 52	
N. B—205	1,380.7	297 14	
205—202	1,446.4	78 26	37.60
202—204	1,836.1	303 25	
204—205	1,306.0	174 55	36.49
205—205 *a*	2,123.1	321 41	
a 205—204	1,255.1	106 54	59.08
a 205—206	1,601.8	41 01	
206—204	1,580.5	174 34	36.19
204—207	1,545.8	317 36	
207—206	991.6	64 11	54.02
207—208	1,210.5	23 59	
208—206	784.1	149 17	35.18
206—209	1,046.4	294 48	
209—208	597.5	66 49	46.14
209—210	1,073.0	358 41	
210—208	1,015.3	145 35	35.48
208—211	1,048.0	287 11	
211—210	679.1	39 00	38.24
210—212	1,010.0	303 41	
212—211	1,163.4	159 13	34.64
211—213	1,317.0	293 14	
213—212	979.0	54 32	44.66
212—214	1,047.7	270 40	
214—213	632.0	156 40	35.07
213—215	871.9	289 54	
215—214	636.1	63 32	34.92
214—216	863.1	289 31	
216—215	522.0	147 40	36.77
215—217	624.9	283 12	
217—216	453.3	47 02	46.98
216—218	659.0	291 52	

*High Die base line.

TABLE 1.—*Tabulated results of the tertiary triangulation of Red River, etc.*—Cont'd.

Side.	Distance.	Azimuth.	Elevation.
	Meters.	° ′	*Meters.*
218—217	621.1	153 13	34.96
217—219	1,050.4	293 38	
219—218	695.3	78 56	46.81
218—220	941.9	310 17	
220—219	743.2	177 13	36.48
219—221	906.1	300 20	
221—220	857.7	73 48	34.66
220—222	1,324.7	288 07	
223—221	783.4	146 15	36.59
221—223	1,347.5	277 24	
223—222	1,019.8	82 04	33.99
222—224	1,279.0	291 05	
224—223	982.4	162 41	35.90
223—225	1,118.1	304 15	
225—224	703.8	63 58	32.90
224—226	1,249.2	280 57	
226—225	897.0	132 36	35.47
225—227	869.6	269 48	
227—226	614.6	26 38	41.51
226—229	935.4	245 03	
229—227	593.0	105 08	41.32
227—228	806.2	318 36	
228—229	451.8	185 00	35.92
229—231	826.1	294 55	
231—228	795.2	82 37	47.71
228—230	734.4	294 37	
230—231	425.6	196 30	35.35
231—233	775.5	314 02	
233—230	691.0	100 56	34.86
230—232	671.7	321 22	
232—233	471.4	213 21	36.00
233—235	702.3	302 23	
235—232	852.4	88 49	35.15
232—234	982.7	308 57	
234—235	641.3	187 53	33.51
235—235*a*	903.6	324 55	
*a*235—234	627.3	98 43	35.24
234—236	1,038.5	327 09	
236—235*a*	779.4	184 10	33.87
*a*235—237	1,205.1	329 14	
237—236	720.9	110 59	41.55
236—238	1,139.2	328 47	
238—237	720.9	186 36	35.05
237—239	750.2	315 10	
239—238	638.8	73 15	34.41
238—240	1,001.7	292 59	
240—239	653.7	151 39	34.24
239—241	949.1	291 57	
241—240	611.4	68 51	35.20
240—243	1,129.2	295 55	
243—241	841.6	148 03	33.80
241—242	986.5	7 49	
242—243	636.6	245 35	34.23
242—244	690.9	346 13	
244—243	1,022.2	203 57	35.03
243—245	977.1	345 48	
245—244	654.7	91 08	33.08
244—246	681.8	309 37	
246—245	441.1	197 04	34.64
245—247	721.4	337 51	
247—246	471.0	121 33	33.57
246—248	820.2	333 12	
248—247	486.6	183 43	34.53
247—249	582.7	311 06	
249—248	481.7	77 43	33.53
248—250	573.9	309 14	
250—249	406.2	183 13	35.54
249—252	832.4	328 24	
252—250	522.5	117 47	27.71
250—251	888.6	264 52	
251—252	532.1	52 37	33.02
251—254	632.9	359 27	
254—252	529.0	125 51	34.50
252—253	708.6	271 51	
253—254	400.5	44 15	32.69
254—255	722.0	280 36	
255—253	601.1	134 18	33.10
253—256	891.1	347 01	
256—255	594.1	207 09	32.79
255—258	824.4	343 27	
258—256	576.9	126 19	34.18

TABLE 1.—*Tabulated results of the tertiary triangulation of Red River, etc.*—Cont'd.

Side.	Distance.	Azimuth.	Elevation.
	Meters.	° ′	*Meters.*
256—257	996.4	268 37	
257—258	645.0	55 27	35.02
258—260	608.9	297 45	
260—257	619.3	179 19	34.66
257—N. B	613.0	268 23	
N. B.—S. B*	518.3	340 08	
S. B.—260	801.0	77 07	35.92
260—N. B	899.6	222 14	
260—260*a*	983.2	331 56	
*a*260—S. B	1,093.6	196 55	35.69
S. B.—261	1,160.6	333 40	
261—260*a*	833.3	89 34	35.63
*a*260—262	1,560.7	335 12	
262—261	1,434.2	187 10	38.18
261—263	1,492.7	325 44	
263—262	1,036.7	79 28	36.41
262—264	1,665.2	311 26	
264—263	1,311.6	105 56	36.34
263—265	1,660.4	304 50	
265—264	1,148.2	70 49	35.63
265—265*a*	1,157.3	00 47	
*a*265—264	1,323.1	126 07	35.20
264—266	1,334.8	354 06	
266—265*a*	1,080.6	239 33	34.82
*a*265—267	1,509.1	13 29	
267—266	1,087.2	147 47	35.08
266—268	1,629.3	18 47	
268—267	1,267.9	240 35	36.10
267—269	1,652.2	3 33	
269—268	1,434.3	135 41	34.47
268—270	2,170.3	6 49	
270—269	1,691.2	228 08	42.20
269—270	1,623.6	328 11	
271—270	2,130.5	96 46	34.95
270—271	1,818.6	331 27	
272—271	1,834.1	222 49	30.09
272—272*a*	1,416.2	312 32	
*a*272—271	2,311.6	185 02	35.28
271—273	2,548.4	327 30	
273—272*a*	1,577.7	84 25	33.11
*a*272—274	1,641.9	332 22	
274—273	1,800.9	206 45	34.85
273—275	1,769.2	336 14	
275—274	1,523.8	90 25	33.10
274—277	2,080.4	306 50	
277—275	1,241.1	173 28	33.86
275—276	1,700.4	38 47	
276—277	1,209.7	265 45	34.91
276—278	1,677.0	319 03	
278—277	1,360.4	184 31	32.26
277—279	1,699.0	309 05	
279—278	1,454.1	78 42	32.37
278—280	1,434.1	305 34	
280—279	1,148.7	193 03	31.96
280—282	1,825.9	282 50	
282—279	2,153.6	135 05	32.95
279—281	1,881.0	273 44	
281—282	1,446.7	14 15	31.53
281—283	1,243.6	322 54	
283—282	1,179.9	69 39	32.45
282—284	1,399.5	296 05	
284—283	1,035.7	171 39	32.81
283—285	1,661.6	272 43	
285—284	1,781.4	57 55	31.72
284—286	2,461.8	283 07	
286—285	1,747.3	149 27	32.78
285—285*a*	1,537.1	263 29	
*a*285—286	1,796.6	20 50	31.42
*a*285—287	1,826.3	280 05	
287—286	2,790.6	60 51	31.01
286—288	3,813.9	282 53	
288—287	2,554.3	149 54	31.33
287—289	2,313.6	289 14	
289—288	1,707.6	32 09	32.24
288—290	1,928.9	258 09	
290—289	1,439.8	136 56	32.56
289—289*a*	1,286.6	276 41	
*a*289—290	919.3	18 06	31.40
*a*289—291	1,285.3	296 36	

* Colfax base line.

TABLE 1.—*Tabulated results of the tertiary triangulation of Red River, etc.*—Cont'd.

Side.	Distance.	Azimuth.	Elevation.
	Meters.	° ′	*Meters.*
291—290	1,480.5	77 15	31.15
290—292	2,150.9	298 12	
292—291	1,417.1	161 25	30.24
291—293	2,220.9	298 27	
293—292	1,528.0	79 15	30.67
292—294	1,875.2	342 39	
294—293	2,278.7	204 25	31.58
293—295	1,737.0	343 41	
295—294	1,480.9	74 04	30.56
294—296	2,085.9	293 55	
296—295	1,340.4	159 10	30.97
295—297	2,094.4	285 00	
297—296	1,703.8	65 19	29.66
296—298	2,096.5	310 20	
298—297	2,068.5	178 34	30.93
297—299	2,456.1	299 52	
299—298	2,242.8	67 54	46.52
298—S. W. B	883.4	326 12	
S. W. B.—N. E. B*	955.7	261 48	31.58
N. E. B.—299	1,702.9	207 06	30.21
N. E. B.—298	1,465.5	117 18	
298—300	2,856.4	316 25	
300—299	2,914.9	182 08	29.34
299—301	1,875.8	330 12	
301—300	1,653.9	39 00	29.84
301—303	1,117.4	208 52	
303—300	2,152.8	69 44	30.49
300—302	1,541.5	288 13	
302—303	1,347.5	204 20	28.23
302—304	1,239.5	304 28	
304—303	1,984.8	166 24	28.19
303—305	1,721.4	310 41	
305—304	1,165.0	46 08	29.80
305—307	1,437.0	328 17	
307—304	1,648.5	104 35	28.35
304—306	1,408.6	325 01	
306—307	1,080.3	226 50	28.14
306—308	1,070.5	306 28	
308—307	1,377.3	176 58	27.65
307—309	1,001.2	318 10	
309—308	865.9	43 23	30.26
308—310	1,293.9	306 57	
310—309	1,474.1	162 39	27.90
309—311	1,566.2	312 20	
311—310	800.0	63 52	29.89
310—312	937.9	326 20	
312—311	1,150.2	189 56	27.77
311—313	1,154.9	329 32	
313—312	795.9	80 03	29.49
312—314	1,074.2	301 28	
314—313	710.7	169 16	27.54
313—315	844.3	299 51	
315—314	661.4	65. 08	30.42
314—316	1,037.1	312 50	
316—315	996.1	170 43	28.86
315—317	1,246.3	313 51	
317—316	747.8	80 48	29.59
316—318	533.2	320 16	
318—317	662.1	216 52	28.39
318—S. W. B	951.9	269 40	
S. W. B.—317	763.1	133 23	29.09
317—N. E. B	1,101.8	281 17	
N. E. B.—S. W. B†	603.8	59 35	29.39

* Alexandria base line.
† Grand Bend base lines.

NOTE.—One meter = 3.280869 feet. Azimuth is measured from zero south in the direction clock hands move. To derive "true bearings" from azimuth: between 0° and 90° the azimuth itself is the southwest course; from 90° to 180°, subtract the azimuth from 180° and the remainder is the northwest course; from 180° to 270°, the northeast course is azimuth minus 180°; and from 270° to 360°, the southeast course is 360° minus the azimuth.

TABLE 2.—*Precise levels.*

[Observers: T. C. Thomas, T. G. Rombauer, W. H. Polk, E. T. Washburn, E. J. Thomas, R. S. Buck, jr.]

INSTRUMENTAL CONSTANTS.

Table A.

Kern level.	Pivot correction for a distance of 1 meter.	Date of determination.
	Millimeters.	
L. S. No. 1	+0.010	Feb. 16, 1889
L. S. No. 1	+0.018	June 4, 1889
L. S. No. 1	+0.021	Oct. 17, 1889
M. R. C. No. 1	−0.016	Feb. 16, 1889
M. R. C. No. 1	−0.006	Oct. 17, 1889
M. R. C. No. 2	+0.014	May 29, 1889
M. R. C. No. 2	+0.002	Dec. 28, 1889

Table B.

Bubble tube.	Value 1 division for a distance of 1 meter.	Date of determination.
	Millimeters.	
No. 4	0.016	Feb. 16, 1889
No. 4	0.016	June 4, 1889
No. 4	0.022	Oct. 18, 1889
No. 1	0.013	Feb. 16, 1889
No. 1	0.008	July 5, 1889
No. 1	0.014	Oct. 18, 1889
No. 2	0.015	June 4, 1889
No. 2	0.021	Dec. 28, 1889

Table C.

Rod.	Length of 1 meter on rod.	Correction for spur.
	Millimeters.	*Millimeters.*
II	999.866*	+47.5
IV	999.890*	+48.2
XV	1,000.053†	−55.5
XVI	1,000.011†	−55.9

* Mean of Lake Survey and Mississippi River Commission determinations. See M. R. C. Rep. 1881, page 51.

† As determined by the Mississippi River Commission. See M. R. C. Rep. 1884, page 58.

Tabulated results.

DELTA, LOUISIANA, TO SHREVEPORT, LOUISIANA.

Bench.	Distance— Between B. Ms.	Distance— From Delta.	Difference of elevation. West.	Difference of elevation. East	Difference of elevation. Mean.	Observer.
	Kilos.	*Kilos.*	*Meters.*	*Meters.*	*Meters.*	
C. and G. Survey, P. B. M., No. 215						
C. and G. Survey. △ S. W. base	0.1	0.1	−1.2435 −1.2459	−1.2496	−1.2463	T. T. and R.
C. B. M.:						
1	1.9	2.0	−0.0290	−0.0231	−0.0260	R.
2	1.2	3.2	−0.0433	−0.0418	−0.0425	T. T.
3	0.8	4.0	+0.2754	+0.2792	+0.2773	T. T.
4	2.0	6.0	−1.1491	−1.1525	−1.1508	R.
5	2.2	8.2	+0.6403	+0.6367	+0.6385	T. T.
6	2.7	10.9	−0.1209	−0.1312	−0.1260	R.
7	2.1	13.0	+0.7388	+0.7412	+0.7400	T. T.
8	3.5	16.5	−2.0106	−2.0072	−2.0089	R.
9	2.3	18.8	−0.3586	−0.3553	−0.3569	T. T.
10	2.4	21.2	+1.5064	+1.5116	+1.5090	R.
11	3.2	24.4	−0.3484	−0.3375	−0.3429	T. T.
11½	1.7	26.1	+1.8159	+1.8220	+1.8190	R.
12	1.4	27.5	−3.4498	−3.4450	−3.4474	R.
13	2.1	29.6	−1.0458	−1.0384	−1.0421	T. T.
14	1.7	31.3	+0.3248	+0.3317	+0.3282	T. T.
15	1.2	32.5	+2.7457	+2.7507	+2.7482	T. T.
16	1.8	34.3	−0.6563	−0.6508	−0.6535	R.
17	1.6	35.9	−0.0514	−0.0456	−0.0485	R.
18	2.0	37.9	+0.3648	+0.3739	+0.3693	T. T.
19	2.2	40.1	−0.4186	−0.4273	−1.4229	T. T.
20	1.7	41.8	+0.0789	+0.0840	+0.0819	R.
21	2.1	43.9	−1.7118	−1.7048	−1.7083	T. T.
22	1.8	45.7	+1.7197	+1.7173	+1.7185	R.

Tabulated results—Continued.

DELTA, LOUISIANA, TO SHREVEPORT, LOUISIANA—Continued.

Bench.	Distance.		Difference of elevation.			Observer.
	Between bench-marks.	From Delta.	West.	East.	Mean.	
C. B. M.—Continued.	*Kilos.*	*Kilos.*	*Meters.*	*Meters.*	*Meters.*	
23	2.2	47.9	+0.3301	+0.3258	+0.3280	T. T.
24	2.9	50.8	−0.4074	−0.4101	−0.4037	R.
25	1.6	52.4	+0.4650	+0.4641	+0.4645	T. T.
26	2.1	54.5	+0.9320	+0.9403	+0.9361	R.
27	1.0	55.5	+1.1013	+1.0995	+1.1004	T. T.
28	1.5	57.0	+1.7522	+1.7771	+1.7546	T. T.
29	1.7	58.7	−2.7615	−2.7601	−2.7608	R.
30	2.1	60.8	−0.5914	−0.5997	−0.5955	R.
31	1.3	62.1	+1.4792	+1.4820	+1.4806	T. T.
32	2.3	64.4	−1.2130	−1.2044	−1.2087	R.
33	2.1	66.5	−0.1439	−0.1415	−0.1427	T. T.
34	2.8	69.3	−0.0698	−0.0673	−0.0686	R.
35	3.4	72.7	−1.6697	−1.6695	−1.6696	T. T.
36	1.9	74.6	−0.2831	−0.2946	−0.2888	T. T.
37	2.5	77.1	−0.8820	−0.8788	−0.8804	R.
38	2.5	79.6	+1.5919	+1.5988	+1.5953	T. T.
39	2.7	82.3	−0.8871	−0.8821	−0.8846	R.
40	3.3	85.6	+0.6488	+0.6430	+0.6459	T. T.
41	2.4	88.0	−1.0122	−1.0138	−1.0130	R.
42	2.8	90.8	−3.0558	−3.0450	−3.0504	T. T.
42½	2.6	93.4	−0.2879	−0.2909	−0.2894	R.
43	1.6	95.0	+1.0882	+1.0860	+1.0871	R.
44	2.6	97.6	−0.0142	−0.0197	−0.0170	T. T.
45	3.0	100.6	−2.4375	−2.4376	−2.4376	R.
46	2.2	102.8	+1.2376	+1.2404	+1.2390	T. T.
47	2.7	105.5	+1.7872	+1.7870	+1.7871	R.
48	1.7	107.2	+0.3239	+0.3245	+0.3242	T. T. and P.
49	3.2	110.4	−0.9294	−0.9215	−0.9255	R.
50	3.2	113.6	+0.0063	+0.0149	+0.0106	T. T.
51	2.0	115.6	+2.5830	+2.5825	+2.5827	R.
52	2.8	118.4	−0.4022	−0.3925	−0.3974	T. T.
53	1.7	120.1	+6.6276	+6.6228	+6.6252	T. T.
54	4.2	124.3	+6.8931	+6.8849	+6.8890	R.
55	1.7	126.0	−6.7993	−6.7983	+6.7988	T. T.
56	2.3	128.3	−0.8044	−0.7988	−0.8016	R.
57	2.0	130.3	+1.9239	+1.9144	+1.9191	T. T.
58	0.9	131.2	−1.7010	−1.6982	−1.6996	T. T.
59	2.0	133.2	+2.4184	+2.4180	+2.4182	R.
60	1.5	134.7	+13.8907	+13.8929	+13.8918	P.
61	1.4	136.1	−10.2144	−10.2141	−10.2143	W.
62	1.9	138.0	+14.1808	+14.9797	+14.1802	R.
63	2.4	140.4	+8.2597	+8.2572	+8.2585	W.
64	2.6	143.0	−4.0721	−4.0681	−4.0701	R.
65	2.9	145.9	−15.7384	−15.7362	−15.7373	W
66	7.0	152.9	+8.2665	+8.2655	+8.2660	R.
67	1.3	154.2	−3.4797	−3.4812	−3.4804	W.
68	1.7	155.9	+2.9036	+2.8986	+2.9011	R.
69	3.4	159.3	+18.7667	+18.7610	+18.7638	W.
70	3.6	162.9	+10.9680	+10.9710	+10.9695	R.
71	2.0	164.9	+18.4824	+18.4837	+18.4831	W.
72	2.6	167.5	−17.2477	−17.2458	−17.2467	R.
73	3.8	171.3	+7.7626	+7.7599	+7.7612	R.
74	2.5	173.8	+15.5714	+15.5732	+15.5723	W.
75	2.9	176.7	−5.1150	−5.1142	−5.1146	R.
76	1.2	177.9	+10.3824	+10.3864	+10.3844	W.
77	3.4	181.3	−7.2878	−8.2813	−8.2845	R.
78	1.7	183.1	+8.2109	+8.2083	+8.2096	W.
79	2.8	185.9	− 3.2217	− 3.2159	− 3.2188	R.
80	2.5	188.4	+ 4.8203	+ 4.8244	+ 4.8223	W.
81	3.6	192.0	+ 1.9307	+ 1.9302	+ 1.9304	R.
82	2.9	194.9	− 6.3545	− 6.3449	− 6.3512	W.
83	3.1	198.0	−22.8284	−22.8219	−22.8251	R.
84	2.6	200.6	− 0.3138	− 0.3101	− 0.3119	W.
85	2.7	203.3	− 9.8658	− 9.8625	− 9.8641	R.
86	3.3	206.6	− 3.2188	− 3.2086	− 3.2137	W.
87	3.0	209.6	− 2.3510	− 2.3517	− 2.3513	R.
88	2.1	211.7	+ 3.5168	+ 3.5177	+ 3.5172	W.
89	2.8	214.5	+ 2.1946	+ 2.1947	+ 2.1946	R.
90	3.4	217.9	− 6.7964	− 6.7934	− 6.7949	W.
91	2.9	220.8	+18.4599	+18.4579	+18.4589	R.
92	1.5	222.3	+ 2.3616	+ 2.3652	+ 2.3634	W.
93	1.3	223.6	− 7.9681	− 7.9677	− 7.9679	R.
94	1.8	225.4	−13.6065	−13.6030	−13.6047	R.

Tabulated results—Continued.

DELTA, LOUISIANA, TO SHREVEPORT, LOUISIANA—Continued.

Bench.	Distance.		Difference of elevation.			Observer.
	Between bench-marks.	From Delta.	West.	East.	Mean.	
C. B. M.—Continued.	*Kilos.*	*Kilos.*	*Meters.*	*Meters.*	*Meters.*	
95	1.6	227.0	−7.3752	−7.3703	−7.3728	W.
96	1.5	228.5	+5.9796	+5.9758	+5.9777	R.
97	1.1	229.6	−11.0220	−11.0254	−11.0237	R.
98	0.9	230.5	−5.0622	−5.0645	−5.0633	W.
99	2.9	233.4	+8.8877	+8.8809	+8.8293	R.
100	1.9	235.3	+0.6971	+0.6932	+0.6951	W.
101	2.8	238.1	+7.0439	+7.0373	+7.0406	R.
102	2.1	240.2	+5.4396	+5.4447	+5.4421	W.
103	2.2	242.4	−3.1581	−3.1545	−3.1563	R.
104	1.5	243.9	−7.8013	−7.8000	−7.8007	W.
105	2.2	246.1	+8.8799	+8.8804	+8.8816	W.
106	2.6	248.7	+6.8795	+6.8837	+6.8816	R.
107	3.8	252.5	+6.3187	+6.3119	+6.3153	R.
108	2.1	254.6	−16.6279	−16.6341	−16.6310	W.
109	1.0	255.6	−9.0705	−9.0687	−9.0696	P.
110	3.0	258.6	+0.6333	+0.6413	+0.6373	R.
111	1.4	260.0	−2.9451	−2.9431	−2.9441	W.
112	3.4	263.4	+0.5331	+0.5272	+0.5302	R.
113	2.4	265.8	+0.0883	+0.0831	+0.0857	W.
114	2.8	268.6	+0.8209	+0.8173	+0.8191	R.
115	1.2	269.8	−0.0685	−0.0632	−0.0658	E. T.
116	1.4	271.2	+5.1210	+5.1187	+5.1198	R.

SHREVEPORT, LOUISIANA, TO GRAND BEND, LOUISIANA.

Bench.	Distance.		Difference of elevation.			Observer.
	Between bench-marks.	From Shreveport.	South.	North.	Mean.	
T. B. M:	*Kilos.*	*Kilos.*	*Meters.*	*Meters.*	*Meters.*	
117	2.0	2.0	−3.5870	−3.5826	−3.5848	E. T.
118	2.8	4.8	−1.2191	−1.2226	−1.2209	E. T.
119	2.3	7.1	+0.6359	+0.6432	+0.6396	R.
120	1.8	8.9	−1.0273	−1.0317	−1.0295	E. T.
121	2.5	11.4	−0.4612	−0.4582	−0.4597	E. T.
122	1.6	13.0	+0.7091	+0.7036	+0.7063	R.
123	2.3	15.3	−1.1094	−1.1035	−1.1065	R.
124	2.0	17.3	−1.3361	−1.3362	−1.3361	W.
125	2.3	19.6	−0.7337	−0.7507	−0.7322	E. T.
126	2.6	22.2	+0.7112	+0.7166	+0.7139	R.
127	1.7	23.9	−0.8750	−0.8724	−0.8737	R.
128	1.1	25.0	+0.5561	+0.5556	+0.5558	E. T.
129	2.1	27.1	−0.3437	−0.3430	−0.3433	E. T.
130	2.6	29.7	+0.7701	+0.7755	+0.7728	R.
131	2.9	32.6	−1.3116	−1.3084	−1.3100	E. T.
132	2.4	35.0	−0.5996	−0.6021	−0.6008	R.
133	2.1	37.1	−0.9909	−0.9859	−0.9884	E. T. and P.
134	2.1	39.2	−0.2141	−0.2184	−0.2163	R.
135	2.5	41.7	−0.9373	−0.9344	−0.9359	R.
136	2.2	43.9	+1.3214	+1.3233	+1.3223	R.
137	2.1	46.0	−0.1626	−0.1654	−0.1640	R.
138	1.6	47.6	−0.3640	−0.3617	−0.3628	R.
139	1.6	49.2	+0.5528	+0.5563	+0.5546	R.
140	1.2	50.4	−0.6924	−0.6967	−0.6945	R.
141	2.0	52.4	−0.7584	−0.7540	−0.7562	R.
142	1.3	53.7	+0.0290	+0.0339	+0.0315	R.
143	1.0	54.7	−0.0150	−0.0137	−0.0144	R.
144	1.9	56.6	−0.5093	−0.5094	−0.5094	R.
145	2.0	58.6	−0.5618	−0.5568	−0.5593	R.
146	1.7	60.3	+0.4103	+0.4060	+0.4081	R.
147	2.0	62.3	−1.6378	−1.6449	−1.6414	R.
148	1.4	63.7	+0.9505	+0.9540	+0.9523	R.

Tabulated results—Continued.

SHREVEPORT, LOUISIANA, TO GRAND BEND, LOUISIANA—Continued.

Bench.	Distance.		Difference of elevation.			Observer.
	Between bench-marks.	From Shreveport.	South.	North.	Mean.	
T. B. M.—Continued.	*Kilos.*	*Kilos.*	*Meters.*	*Meters.*	*Meters.*	
149	1.5	65.2	+0.2702	+0.2738	+0.2720	R.
150	1.6	66.8	+0.3804	+0.3819	+0.3811	R.
151	2.0	68.8	−0.5514	−0.5575	−0.5545	R.
152	2.3	71.1	−0.5331	−0.5292	−0.5311	R.
153	2.0	73.1	−2.7110	−2.7066	−2.7088	R.
154	2.6	75.7	+0.4455	+0.4553	+0.4494	R. and P.
155	2.1	77.8	+0.0594	+0.0661	+0.0628	R.
156	2.0	79.8	−0.1494	−0.1437	−0.1465	R.
157	1.5	81.3	+0.6362	+0.6323	+0.6343	R.
158	1.6	82.9	−0.9580	−0.9545	−0.9562	R.
159	1.9	84.8	−0.1111	−0.1089	−0.1100	R.
P. B. M.:						
57	1.1	85.9	+0.0463	+0.0470	+0.0466	R.
T. B. M.:						
1	2.5	88.4	+1.7117	+1.6935	+1.7026	R.
2	2.0	90.4	−2.9657	−2.9662	−2.9659	R.
3	1.7	92.1	+0.0988	+0.0992	+0.0990	R.
4	1.3	93.4	+0.1063	+0.1021	+0.1042	R.
5	1.3	94.7	−0.6659	−0.6636	−0.6647	R.
6	1.0	95.7	+0.4940	+0.4971	+0.4956	R.
7	1.3	97.0	−0.8874	−0.8860	−0.8867	R.
8	1.1	98.1	+3.1280	+3.1330	+3.1305	R.
8½*			−1.0410	−1.0703	−1.0506	R.
9	1.3	99.4	−1.1238	−1.1276	−1.1257	R.
10	0.6	100.0	+0.1780	+0.1758	+0.1769	R.
11	1.6	101.6	+1.4860	+1.4867	+1.4863	R.
12	1.1	102.7	−1.0917	−1.0927	−1.0922	R.
13	1.9	104.6	−0.5487	−0.5523	−0.5505	R.
14	0.9	105.5	−0.0716	−0.0690	−0.0703	R.
15	3.2	108.7	−1.1071	−1.1051	−1.1061	R.
16	1.1	109.8	+0.9904	+0.9875	+0.9889	R.
17	2.6	112.4	−0.7367	−0.7380	−0.7374	R.
18	1.1	113.5	−1.2009	−1.2024	−1.2016	R.
19	2.2	115.7	+0.4252	+0.4269	+0.4260	R.
20	1.3	117.0	+2.0737	+2.0770	+2.0754	R.
21	1.9	118.9	−2.3472	−2.3408	−2.3440	R.
22	1.1	120.0	+1.6931	+1.6956	+1.6943	R.
23	2.5	122.5	−1.3228	−1.3163	−1.3196	R.
24	1.4	123.9	+1.6387	+1.6450	+1.6419	R.
25*			+0.3475	+0.3485	+0.3480	R.
26	2.6	126.5	−1.4153	−1.4087	−1.4120	R.
27	2.0	128.5	−2.4430	−2.4471	−2.4450	R.
28	1.3	129.8	+1.9920	+1.9970	+1.9945	R.
29	0.8	130.6	−0.1097	−0.1116	−0.1107	R.
30	2.0	132.6	+0.1537	+0.1558	+0.1547	R.
31	2.6	135.2	−2.1498	−2.1489	−2.1493	R.
32	1.6	136.8	+1.1788	+1.1809	+1.1799	R.
33	3.0	139.8	−2.1796	−2.1821	−2.1808	R.
34	1.7	141.5	+1.4369	+1.4391	+1.4380	P.
35	0.9	142.4	−0.1520	−0.1557	−0.1539	P.
36	2.7	145.1	−0.8610	−0.8688	−0.8649	R.
37	0.6	145.7	−0.0534	−0.0573	−0.0553	R.
38	2.9	148.6	−0.5915	−0.5886	−0.5900	R.
39	1.9	150.5	−0.0081	−0.0120	−0.0100	R.
40	1.8	152.3	−1.3064	−1.3106	−1.3085	R.
41	1.7	154.0	+0.9099	+0.9085	+0.9092	R.
42	1.1	155.1	−2.3534	−2.3549	−2.3541	R.
43	0.5	155.6	+2.4431	+2.4406	+2.4419	R.
44	1.0	156.6	−2.9926	−2.9967	−2.9946	R.
45	1.0	152.6	+15.4896	+15.4868	+15.4882	R.
46	2.1	150.7	−13.9252	−13.9269	−13.9260	R.
46½	1.6	161.3	+0.1084	+0.1085	+0.1084	R.
47	1.9	163.2	−0.3294	−0.3255	−0.3274	R.
47½	0.4	163.6	+0.2584	+0.2577	+0.2580	R.
48*			+0.6965	+0.7085	+0.7025	R.
49	2.0	165.6	−1.0437	−1.0467	−1.0452	R.
50	1.8	167.4	−0.5747	−0.5744	−0.5745	R.
51	1.7	169.1	−1.1987	−1.2006	−1.1997	R.
52	1.6	170.7	−0.0206	−0.0269	−0.0237	R.
53	2.2	172.9	+0.4916	+0.4951	+0.4933	R.
54	1.5	174.4	+0.5229	+0.5216	+0.5222	R.
55	2.4	176.8	−2.5352	−2.5352	−2.5352	R.
56	0.5	177.3	+0.5690	+0.5680	+0.5685	R.

* River crossing.

Tabulated results—Continued.

SHREVEPORT, LOUISIANA, TO GRAND BEND, LOUISIANA—Continued.

Bench.	Distance.		Difference of elevation.			Observer.
	Between bench-marks.	From Shreveport.	South.	North.	Mean.	
T. B. M.—Continued.	*Kilos.*	*Kilos.*	*Meters.*	*Meters.*	*Meters.*	
57	1.9	179.2	— 0.4060	— 0.4157	— 0.4109	R.
58	1.5	180.7	+ 1.0861	+ 1.0831	+ 1.0846	R.
59	1.1	181.8	— 0.1057	— 0.1097	— 0.1077	R.
60	1.0	182.8	— 1.1602	— 1.1643	— 1.1622	R.
61	0.7	183.5	+ 0.7817	+ 0.7797	+ 0.7807	R.
62	1.1	184.6	— 0.3137	— 0.3087	— 0.3112	R.
63	1.2	185.8	— 0.2963	— 0.2935	— 0.2949	R.
64	1.2	187.0	— 0.3020	— 0.2994	— 0.3007	R.
65	1.2	188.2	+ 0.2839	+ 0.2874	+ 0.2857	R.
66	1.1	189.3	+ 0.0490	+ 0.0523	+ 0.0507	R.
67	1.6	190.9	— 1.7951	— 1.7941	— 1.7946	R.
68	1.3	192.2	+ 0.2122	+ 0.2067	+ 0.2094	R.
68½	1.6	193.8	+ 1.1181	+ 1.1159	+ 1.1170	R.
69*	.....	.....	+ 1.9791	+ 1.9806	+ 1.9798	R.
70	4.1	197.9	— 0.7993	— 0.8032	— 0.8012	R.
71	3.8	201.7	+ 0.0623	+ 0.0568	+ 0.0595	R.
72	2.6	204.3	+ 0.5761	+ 0.5728	+ 0.5744	R.
73	1.6	205.9	— 0.6640	— 0.6679	— 0.6659	R.
74	2.5	208.4	— 0.5605	— 0.5608	— 0.5606	R.
75	1.8	210.2	— 0.2100	— 0.2104	— 0.2102	R.
76	3.1	213.3	— 0.5656	— 0.5635	— 0.5645	R.
77*	.....	.....	— 0.9213	— 0.9223	— 0.9218	R.
78	2.5	215.8	— 0.6132	— 0.6147	— 0.6139	R.
79	2.4	218.2	+0.1642	+0.1690	+0.1666	R.
80	4.0	222.2	+0.2331	+0.2374	+0.2352	R.
81	2.3	224.5	—1.0530	—1.0591	—1.0560	R.
82	3.4	227.9	—0.7438	—0.7479	—0.7458	R.
83	5.1	233.0	—0.5308	—0.5303	—0.5305	R.
84	6.2	239.2	+0.1612	+0.1605	+0.1608	R.
85	1.9	241.1	—2.1739	—2.1680	—2.1709	B.
86	1.2	242.3	+1.9671	+1.9689	+1.9680	B.
87	1.6	243.9	—0.7042	—0.6997	—0.7019	B.
88	1.8	245.7	—0.0447	—0.0408	—0.0427	B.
89	1.7	247.4	—0.1133	—0.1112	—0.1122	B.
90	1.3	248.7	—1.6176	—1.6191	—1.6183	B.
91	1.7	250.4	+1.7916	+1.7921	+1.7918	B.
92	1.9	252.3	—1.2314	—1.2317	—1.2315	B.
93	0.9	253.2	+1.2253	+1.2281	+1.2267	B.
94	1.8	255.0	—1.8699	—1.8701	—1.8700	B.
95	1.3	256.3	+1.1816	+1.1827	+1.1821	B.
P. B. M. 3						
96	0.3	256.6	—1.3693	—1.3725	—1.3709	B.

* River crossing.

TABLE 3.—*Descriptions and elevations of precise bench-marks from Delta, Louisiana, to Grand Bend, Louisiana.*

[Assistant Engineer T. G. Rombauer, chief of party.]

[NOTE.—All bench-mark monuments, when not otherwise described, consist of pieces of limestone 46 centimeters square and 15 centimeters thick, marked $\frac{\text{U. S.}}{\text{B. M.}}$ with spherical-headed copper bolts leaded in upper faces, and buried 1.2 meters under ground, access being given through 12-centimeter iron pipes set on top. Each pipe has a cast-iron cover, fastened by a horizontal bolt through cap and pipe. The cap has a small boss and the letters $\frac{\text{U. S. E.}}{\text{B. M.}}$ raised on top. Elevations are expressed in meters above the Cairo Datum and apply to the top of the bolt in the underground stone. Elevation of boss of pipe cap can be found in any case by adding 1.24 meters to elevation of copper bolt.]

C. and G. S. P. B. M. 215. For description, see Report Chief of Engineers, 1885, page 2676. Elevation, 34.084.

P. B. M. 2. At northeast corner of the most easterly of the Vicksburg, Shreveport, and Pacific Railroad section houses at Mound Station, Madison Parish, La. Bench is 0.8 meter south and 0.2 meter east of northeast corner of house. Elevation, 31.522.

P. B. M. 3. In northeast corner of yard of Mrs. N. Thomas at California Station,

Madison Parish, La., about 400 meters south of Vicksburg, Shreveport and Pacific Railroad bridge No. 25. Elevation, 33.070.

P. B. M. 4. In southwest corner of yard around cabin, and opposite store at Barnes Station, Madison Parish, La.; 13.4 meters from southwest corner of cabin chimney, and 44 meters north of center of railroad siding. Elevation, 30.880.

P. B. M. 5. Hole in head of copper bolt leaded horizontally in south wall of court house at Tallulah, Madison Parish, La. Bolt is 0.6 meter west of west side of main door and 0.55 meter above floor of gallery. Elevation, 34.163.

P. B. M. 6. Cross-cut on west end of iron door sill at south entrance of Tallulah court house. It is nearly under P. B. M. 5. Elevation, 33.767.

P. B. M. 7. On east bank of Lake One, 57 meters north of east pier of Vicksburg, Shreveport and Pacific Railroad bridge and in a southwesterly direction from Waddill's saw-mill. Elevation, 29.743.

P. B. M. 8. At northwest corner of store at Quebec Station, Madison Parish, La. Store is 110 meters southwest from west end of railroad siding and 60 meters east of east end of railroad bridge over Bayou Dispute. Elevation, 29.064.

P. B. M. 9. On east bank of Tensas River, in a southeasterly direction from railroad bridge, and in direct range of second bent of east bridge approach, 8.7 meters south of center line of track. Elevation, 29.996.

P. B. M. 10. At Dallas, Madison Parish, La. Bench is 2.35 meters east of brick chimney of first cabin, west of Tensas River, on north side of railroad track, and 4.1 meters north of center line of track. Elevation, 29.409.

P. B. M. 11. In northwest corner of yard of house occupied by section foreman at Waverly, Madison Parish, La. Bench is 55 meters south of center of railroad track, and 20.5 meters north of house, in continuation of west wall. Elevation, 30.118.

P. B. M. 12. On west bank of Bayou Macon, near Vicksburg, Shreveport and Pacific Railroad Bridge. Bench is in direct range of the fourth bent of west bridge approach, 40 meters south of center of track, and 10.8 northeast of blazed locust. Elevation, 28.801.

P. B. M. 13. At Delhi, Richland Parish, La., in northwest corner of residence lot belonging to W. T. Insley. Bench is 27.3 meters south of center line of track, 20.4 meters east of Catholic church-yard fence, and 1 meter south and 1 meter east of northwest fence corner. Elevation, 34.927.

P. B. M. 14. At Carpenter's Station, Richland Parish, La., in southeast corner of yard of cabin standing opposite railroad platform. Bench is 15.4 meters north of center of track, and 23.8 meters southeast of southeast corner of cabin. Elevation, 32.514.

P. B. M. 15. At Holly Ridge, Richland Parish, La.; in yard of residence of W. F. Winstead; 23.4 meters south of front line of gallery; 1.8 meters west of main door to house; and 18.3 meters north of center line of track. Elevation, 32.089.

P. B. M. 16. In court-house yard at Rayville, Richland Parish, La. Bench, 0.8 meter west of northwest corner of "L" in court-house front, 0.9 meter north of north wall, and 61 meters south of center of track. Elevation, 30.662.

P. B. M. 17. Hole in head of copper bolt leaded in face of "L" of court-house front, Rayville, La.; 0.09 meter west of north door, and 0.4 meter above floor line. Elevation, 32.992.

P. B. M. 18. On east bank of Bœuf River, in a southeasterly direction from Vicksburg, Shreveport and Pacific bridge; 70.6 meters south of center line of track, and in direct range of first bent east end of bridge approach; 12.5 meters from river bank, and 200 meters northeast of house. Elevation, 30.573.

P. B. M. 19. At Girard, Richland Parish, La.; east side of yard of Mrs. Brashear; 4 meters east and 4.5 meters south of southeast corner of brick chimney at east end of house; and 26 meters south of center line of track. Elevation, 30.321.

P. B. M. 20. Hole in head of copper bolt leaded in east face of brick chimney at east end of Mrs. Brashear's house at Girard, Richland Parish, La. Bolt is 0.3 meter from north face of chimney and 1 meter above springing course. Elevation, 32.463.

P. B. M. 21. In southeast corner of garden lying in a northwesterly direction from railway platform at Crew Lake Station, Richland Parish, La. Bench is 4.5 meters west of southwest corner of store at Crew Lake, on line of front of store, and 24 meters north of center line of track. Elevation, 26.443.

P. B. M. 23. In northeast corner of yard on plantation of F. L. Whitehead at Gordon Station, Ouachita Parish, La. Bench is 14.7 meters north and 9.5 meters east of northeast corner of brick chimney at east end of an "L" shaped cabin in same yard as bench. Elevation, 25.787.

P. B. M. 24. In grass plot south of round-house at Vicksburg, Shreveport and Pacific shops, Monroe, Ouachita Parish, La. Bench is in southwest corner of plot, 8 meters north of center line of track and 2.4 meters east of east wall of office building. Elevation, 27.994.

P. B. M. 25. In cross-cut on northwest corner of iron-roller plate, set on granite cap

of concrete pier, with sheet-iron casing at north side of east end of bridge, over Ouachita River, at Monroe, Ouachita Parish, La. Elevation, 30.810.

P. B. M. 26. Is an arrow cross (+⟶) cut in granite cap-stone of concrete pier with sheet-iron casing at north side of west end of bridge, over Ouachita River, at Monroe. Elevation, 30.857.

P. B. M. 27. In northwest corner of court-house yard at Monroe. Bench is in line of oak trees parallel to court-house front and midway between two lines of oaks parallel to north wall, 45 meters west and 9 meters north of northwest corner of building. Elevation, 29.964.

P. B. M. 28. In northeast corner of yard of T. C. McLain, West Monroe, Ouachita Parish, La., at southwest corner of Cotton and Natchitoches streets. Bench is 9.2 meters east of center line of McLain's house and 10 meters north of north face of brick chimney at east side of house. Elevation, 29.219.

P. B. M. 29. At northwest corner of section-house yard at Chênière Station, Ouachita Parish, La. Bench is 17.5 meters south of center line of track and 63.7 meters east of Vicksburg, Shreveport and Pacific pile bridge No. 181. Elevation, 33.494.

P. B. M. 30. At northwest corner of yard of C. C. Harris, Calhoun, Ouachita Parish, La. Bench is 18 meters west and 7.5 meters north of northwest corner of Harris's house, and 45 meters south of center of track. Elevation, 56.626.

P. B. M. 32. At Choudrant, Lincoln Parish, La., 1 meter east and 4.4 meters north of southeast corner of Farmers' Union office, and 66 meters north of center line of track. Elevation, 52.596.

P. B. M. 33. In court-house yard, Ruston, Lincoln Parish, La. Bench is 1.5 meters south and 1.5 meters west of southeast corner of brick building used as sheriff's office, at southwest corner of Louisiana and Vienna streets. Elevation, 102.030.

P. B. M. 34. Is 50 meters northwest of platform at Allen Green Station, Lincoln Parish, La., 46 meters north of center line of track, 1 meter east of frame store, and 27 meters northeast of glazed oak. Elevation, 106.818.

P. B. M. 35. In northwest corner of yard of Mr. Madden, Simsboro, Lincoln Parish, La. Bench is 1 meter from street line, 1 meter from fence on west side of yard, and 24.5 meters from northwest corner of house. Elevation, 103.814.

P. B. M. 36. In southeast corner of section house yard at Arcadia, Bienville Parish, La.; 6.7 meters south and 6.5 meters east of southeast corner of the most easterly of four section houses; 24 meters north of center of track. Elevation, 118.649.

P. B. M. 37. In northeast corner of Colbert Hotel yard, Gibbsland Station, Bienville Parish, La. Bench is 1.3 meters south and 1.4 meters west of northeast fence corner, and 31.6 meters south of center of track. Elevation, 79.925.

P. B. M. 38. In northeast corner of gin yard at Taylor Station, Bienville Parish, La. Bench is 12.5 meters north and 8.3 meters east of northeast corner of gin, and 17.5 meters south of center of track. Elevation, 72.711.

P. B. M. 39. In southeast corner of yard of P. H. McCary, Dubberly, Webster Parish, La. Bench 1.1 meters north and 1 meter west of fence corner, and 11.8 meters from southeast corner of brick chimney at south side of house. Elevation, 84.194.

P. B. M. 40. In northwest corner of Mr. Allison's yard, Sibley, Webster Parish, La. Bench is 1.1 meter south and 0.8 meter east of fence corner, 28.8 meters south of center line of track, and 15 meters from northwest corner of house. Elevation, 63.783.

P. B. M. 41. On east bank of Bayou Dorcheat, near Vicksburg, Shreveport and Pacific Bridge. Bench is in direct range of second bent of east bridge approach; 22 meters south of center of track; and 20.5 meters east of draw span of bridge. Elevation, 49.132.

P. B. M. 42. In northwest corner of field owned by D. B. Doyle, at Doyle Station, Webster Parish, La. Bench is 45 meters south of Farmer's Alliance Building, 30 meters southeast of southeast corner of Doyle's store, and directly southwest from station platform. Elevation, 74.221.

P. B. M. 43. In southwest corner of J. T. Edwards's yard, Haughton, Bossier Parish, La. Bench is 11.6 meters south and 10.4 meters west of southwest corner of residence. Elevation, 78.346.

P. B. M. 44. In northeast corner of yard of Oliver Williams, Bodeau Parish, La. Bench is 5.6 meters east and 4.5 meters north of northeast corner of residence, and 24.3 meters south of center of track. Elevation, 68.274.

P. B. M. 45. Same as △ W. B. of Shreveport base line. On west side of Red River, opposite Shreveport, about 300 meters from Bossier end of Vicksburg, Shreveport and Pacific Bridge over Red River, and 20 meters south of track. Bench is in northwest corner of small field, where road from southeast turns northeast along track. Elevation, 58.370.

P. B. M. 46. In northwest corner of yard of the public building at Shreveport, La. Bench is 1.3 meters east and 0.5 meter south of fence corner, and 28 meters north of northwest corner of building. Elevation, 64.433.

P. B. M. 47. In southwest portion of field on Kincaid Place, left bank of Red River, Bossier Parish, La. Bench is 115 meters back of levee on river front, 50

meters east of bank of bayou, and 60 meters northwest from cabin standing east of bayou and back of levee. Elevation, 56.138.

P. B. M. 48. At Lotus Landing, right bank of Red River, Caddo Parish, La. Bench is in northwest corner of yard of Captain Robson's store, 46.5 meters from river, 1.5 meters back of store, and 50 meters south of dwelling house just above the store. Elevation, 54.230.

P. B. M. 49. At bend in levee, about 2,000 meters south of gin on Cash plantation, right bank of river, Caddo Parish, La. Bench is 137 meters from river, 83 meters northwest of bayou, and 3 meters north of thorn tree on outer side of levee. Elevation, 52,599.

P. B. M. 50. Near Caspiana Landing, right bank of river, Caddo Parish, La., on J. H. Hutchinson's plantation. Bench is 2.5 meters east of gin, 126 meters from river, and 40 meters south of public road. Elevation, 51.335.

P. B. M. 51. In southeast corner of Dr. T. Allison's yard, Campo Bello plantation, Caddo Parish, La., right bank. Bench is 97 meters from river, 19 meters north and 3.9 meters east of southeast corner of house, and about 300 meters southeast of gin. Elevation, 50.816.

P. B. M. 52. On Bonner's plantation, Caddo Parish, La., right bank. Bench is 8 meters north and 2 meters east of cabin occupied by S. Smith (colored), 183 meters from river, and 300 meters southwest of a gin standing at first bend of river to the left below Bear Point Landing. Elevation, 50.077.

P. B. M. 53. On Stringfellow's plantation, near Howard post-office, Red River Parish, La., right bank of river. Bench is in southwest corner of yard of cabin occupied by S. Johnson (colored), 23.5 meters south and 6.8 meters west of cabin. Cabin stands 300 meters southwest of plantation house and 200 meters south of gin. It is the first cabin south of post-office. Elevation, 49.273.

P. B. M. 54. In yard of Thomas Bell, just below mouth of Loggy Bayou, on left bank of river. Bench is 10.4 meters north of residence and 45 meters from river bank. Elevation, 50.005.

P. B. M. 55. In southwest corner of lot owned by W. P. Scarborough, at East Point, Red River Parish, La. Bench is 16.5 meters from river, 3.5 meters south of James Foley's warehouse, and 0.9 meter from front fence of lot. Elevation, 49.391.

P. B. M. 56. On Crichton's plantation, Red River Parish, La., left bank of river. Bench is in southwest corner of yard around two cabins standing where river makes an abrupt turn to the right. Cabins are about 400 meters below Mr. Crichton's residence and 100 meters to left of the public road. Elevation, 48.164.

P. B. M. 57. In northwest corner of court-house yard at Coushatta, Red River Parish, La. Bench is 1 meter from north fence line, 1 meter from west fence line; and 33.2 meters from northwest corner of court-house. Elevation, 46.489.

P. B. M. 58. In northwest corner of yard of Methodist church, at Coushatta, La. Bench is 0.8 meter, from north fence line, 0.9 meter from west fence line 31 meters from east fence line, and 7.9 meters from northwest corner of church. Elevation, 46.913.

P. B. M. 59. On Upper Brownsville plantation, Red River Parish, La., in northeast corner of garden back of a negro cabin, standing about 600 meters southeast of Lake End Landing and 300 meters from bank. Bench is 10 meters southeast of southeast corner of cabin. Elevation, 44.718.

P. B. M. 60. On property of George Johnson (colored), next below Boyce plantation, Natchitoches Parish, La., right bank. Property lies just above Old River and to left of public road to Campti. Bench is 1.8 meters from north line of residence and on line with front of gallery. Elevation, 43.112.

P. B. M. 61. In northwest corner of yard of S. O. Melancon, Le Vassar plantation, Natchitoches Parish, La., at lower end of Closs Point Bend, about 3 kilometers below Campti, La. Bench is 8.5 meters northeast of front line of gallery and 6.3 meters northwest of northwest line of house. Elevation, 42.385.

P. B. M. 62. In small yard adjoining Willow post-office building, Natchitoches Parish, La. Bench is 3.5 meters south of south line of post-office, and 3 meters west of west line of post-office. Elevation, 42.461.

P. B. M. 63. In southwest corner of yard of H. P. Gallion, Nacthitoches Parish, La., opposite lower end of Tiger Island, and on east bank of Fausse River just above where it branches. Bench is 39 meters west of west line of gallery of residence and 5.5 meters south of south line of residence. Elevation, 40.562.

P. B. M. 64. At St. Maurice, Winn Parish, La., in southeast corner of inclosure southeast of E. W. Tedlie's store, 0.8 meter northwest of northwest line of front gallery, and 5.2 meters southwest of southwest line of store. Elevation, 39.005.

P. B. M. 65. On plantation of C. C. Dunn, Grant Parish, La., near a cabin standing 375 meters above Dunn's Landing. Bench is 5.1 meters south of south wall of cabin and 8 meters east of east wall. Elevation, 38.109.

P. B. M. 66. On plantation of Dr. R. E. Jackson, Natchitoches Parish, La., about 1.5 kilometers below town of Montgomery and on right bank. Bench is in northeast

corner of Dr. Jackson's yard, 31.6 meters east of east wall of house, and 23.3 meters north of north wall. Elevation, 36.413.

P. B. M. 67. On J. A. Williams's plantation at Buxton's Landing, Natchitoches Parish, La. Bench is 60 meters east of east wall of plantation house and 14 meters south of south wall. House stands 80 meters below mouth of Little River. Elevation, 34.297.

P. B. M. 68. *On right bank, opposite dwelling-house on plantation of Isaac McMills, and about 6.4 kilometers above town of Colfax, La. Bench is referenced as follows:* No. 1, blazed oak tree southwest of bench, 6 meters distant; No. 2, blazed oak northwest of bench, 11 meters distant; No. 3, △ 248 north of bench, 70 meters distant; △ 248 is on river bank 260 meters below mouth of small bayou. Elevation, 32.576.

P. B. M. 69. *In northwest corner of court-house yard, at southeast corner of Second and Main streets, Colfax, Grant Parish, La. Bench is 8.4 meters north of north wall of court-house and 16.2 meters west of west wall.* Elevation 35.498.

P. B. M. 70. *On plantation of Mrs. A. C. Deal, Grant Parish, La., about 2 kilometers above Fairmount post-office and opposite De Loache's Rock. Bench is in southeast corner of yard on west side of Mrs. Deal's store, 5 meters south of south wall of store, and 9.4 meters west of east wall.* Elevation 35 001.

P. B. M. 71. *At Boyce, Rapides Parish, La., next to fence in field belonging to Mr. Boyce, and at angle of lane running back from warehouse, along north side of town. Bench is 42 meters west of east wall of J. T. Carnahan's residence, and 37.1 meters north of north wall.* Elevation, 32.348.

P. B. M. 72. *On Mr. Marye's plantation, Rapides Parish, La., about 5.6 kilometers below Rapides post-office. Bench is on small levee 0.7 meter northwest of intersection of levee with division fence between Marye's and Cruckshank's plantations, and 4 meters southeast of angle in levee where it changes its course from southwest to southeast.* Elevation, 30.091.

P. B. M. 73. *In south corner of court-house yard, corner of Lee and Second streets, Alexandria, La. Bench is 26.7 meters southwest of southwest wall of court-house, and 21.3 meters southeast of southeast wall.* Elevation, 28.642.

P. B. M. 74. *In east corner of yard of Rapides Parish jail, Alexandria, La., on Lee street, between Fifth and Sixth streets. Bench is 3.2 meters southeast of southeast wall of jail, and 10 meters northeast of northeast wall.* Elevation, 27.795.

P. B. M. 75. *On plantation of C. O. Harris, Rapides Parish, La.; right bank about 8 kilometers below Alexandria, La., and near a cabin standing 32 meters west of a point on levee which is 22.5 meters below bend in levee opposite and little above Cannon's wood-yard. Bench is 6.3 meters north of north wall of cabin, 17.2 meters east of east wall, and 16 meters back of levee.* Elevation, 28.274.

P. B. M. 76. *Same as* △ *southwest base of Grand Bend base line, and is on Peart's plantation, Rapides Parish, La., on neck of Grand Bend. Bench is about midway on neck, at side of fence dividing pasture and thicket, on thicket side.* Elevation, 27.846.

TABLE 4.—*Descriptions and elevations of bench-marks from Fulton, Arkansas, to Shreveport, Louisiana.*

[E. J. Thomas, leveler.]

[NOTE.—Elevations are in meters above Cairo datum, and apply to top of bolt in underground stone. Elevation of boss of pipe-cap can be found in any case by adding 1.24 metres to the tabular elevation.]

B. M. 1. On north side of Mount Prairie street, Fulton, Ark., in southeast corner of B. F. Davis's yard, 125 feet from railway (side track) and about 500 feet from large warehouse on river bank. Elevation, 83.52.

B. M. 2. At northeast corner of Washington and Orleans streets, Fulton, Ark., in southeast corner of Gus. Taylor's yard, opposite Heath's Hotel. Elevation, 84.02.

B. M. 3. At northeast corner of house of Gib Adams, about 1,000 feet back of Adams Landing, and 50 feet south of Fish Bayou. Bench is 2 feet from house. Elevation, 82.03.

B. M. 4. At northeast corner of St. Louis, Arkansas and Texas Railroad section house at Garland City, Ark. It is 2,020 feet from center pier of railroad bridge, measured along railroad track, and 70 feet north of track. Elevation, 76.53.

B. M. 5. On Cryer's plantation, on top of levee, and at southwest corner of old field, just above negro house, and about 400 feet from river. The bench is just above first point on right bank below Dr. Candler's. Elevation, 74.23.

B. M. 6. On Brooker's plantation; 1,000 feet above store at landing. Bench is at hand in levee, 300 feet above frame shanty standing inside the levee. Elevation, 73.00.

B. M. 7. At northeast corner of store at Collin's Bluff; 4 feet from north face and 1 foot from east face of building. Elevation, 75.73.

B. M. 8. At southeast corner of Dr. Vance's residence; 1,000 feet above Gilmer's Landing and 500 feet from river. Elevation, 73.90.

B. M. 9. At northeast corner of cabin in field lying between the two branches of Cow Bayou; about 2,500 feet above Dixon's store, and 400 feet back of levee across mouth of bayou. Elevation, 64.07.

B. M. 10. At southeast corner of cabin 1,000 feet back of store at Beazley's Landing; 30 feet from fence along edge of the clearing. Elevation, 63.14.

B. M. 11. On Corner plantation; about 2,500 feet below Cottonwood Bayou; at corner of third cabin back from river, along a small slough emptying into the river near steam gin. Elevation, 61.75.

B. M. 12. On back levee of Soda Fountain plantation, near corner where levee turns and runs toward river along line between Soda Fountain and Carolina plantations. Elevation, 61.21.

B. M. 13. On John Eric's plantation, 800 feet back of gin, standing just below ferry; at corner of field back of and below plantation house. Elevation, 60.22.

B. M. 14. At southwest corner of Gold Point plantation, about 600 feet from river and 150 feet from cabin on Silver Point plantation. Bench is at intersection of lines running on lines S. and N. and E. and W., respectively. Elevation, 59.18.

B. M. 15. On Pandora plantation, about 1,000 feet above White Hall or White Cliff Ferry. Bench is on levee, at first bend in same, above ferry. Elevation, 61.40.

B. M. 16. On Southside plantation, at top of levee running back from river along small bayou, separating Southside and Cuba plantations. Bench is about 800 feet from river. Elevation, 60.04.

B. M. 17. On E. B. Herndon's place, about 2½ miles above Shreveport, back of cabin standing opposite plantation house of Dr. Diliard, about 600 feet from river. Elevation, 59.39.

TABLE 5.—*Elevations of river section reference points from Shreveport, Louisiana, to Grand Bend, Louisiana.*

[Topographers, R. S. Buck, jr., F. B. French, E. T. Washburn. Leveler, C. H. Schermerhorn.]

[NOTE.—These reference points are placed in lines normal to river channel at intervals of about 8 kilometers, four reference points in each line. Any reference point is designated by the number of its line, counting from line No. 1 at Shreveport, and by its number in the line counting from *point* No. 1 at outer end of line on right bank to No. 4 at outer end on left bank. *Points* marked by vitrified pipes set in ground and filled with cement. Elevations are in meters above Cairo datum.]

Number of line.	Elevations.				Number of line.	Elevations.			
	1	2	3	4		1	2	3	4
1	58.27	59.06	58.68	58.24	25	44.04	45.07	43.68	44.38
2	54.59	56.76	57.09	56.00	26	43.86	43.90	41.44	42.42
3	56.18	56.34	56.12	55.68	27	43.76	37.69	43.23	44.01
4	55.34	56.54	57.10	55.08	28	38.59	39.57	43.31	40.97
5	55.46	54.96	56.52	53.60	29	41.72	42.11	42.06	41.02
6	53.17	54.56	54.33	53.38	30	37.08	40.23	39.48	38.76
7	52.61	53.23	54.01	53.13	31	39.12	39.87	39.54	39.68
8	53.10	53.89	52.95	51.62	32	38.67	38.82	37.88	45.55
9	52.93	53.02	53.08	52.85	33	36.73	37.62	37.11	36.10
10	51.59	52.15	52.42	53.06	34	35.46	34.95	45.77	49.54
11	51.28	53.03	52.39	51.58	35	34.76	33.26	34.00	36.38
12	50.64	51.62	52.12	51.21	36	33.05	33.92	34.39	33.52
13	50.81	51.94	51.42	51.36	37	34.37	34.58	33.43	32.66
14	50.80	50.48	50.35	49.19	38	34.36	36.56	36.03	36.04
15	49.94	51.11	50.75	49.99	39	34.43	36.21	36.14	34.55
16	50.01	50.21	50.25	49.96	40	31.53	32.44	35.95	34.33
17	48.59	49.34	49.69	49.35	41	34.54	34.64	34.28	33.60
18	46.53	47.60	50.05	48.29	42	31.47	32.52	31.68	32.09
19	47.91	49.20	47.46	47.00	43	31.80	32.23	31.42	30.81
20	47.63	48.76	49.11	47.33	44	30.09	29.82	31.90	30.78
21	47.10	47.48	48.35	48.26	45	30.89	29.91	31.09	30.25
22	46.09	47.01	46.44	46.21	46	29.42	30.23	31.05	38.17
23	45.85	47.42	44.92	46.14	47	29.34	29.05	28.53	27.73
24	45.72	46.44	45.08	45.62	48	28.55	29.56	28.74	40.42

TABLE 6.—*Descriptions of permanent reference points from Fulton, Arkansas, to Shreveport, Louisiana.*

[NOTE.—Elevations are given wherever determined, and are expressed in meters above the Cairo datum. The elevations given apply to top of bolt in the under-ground stone. Elevation of boss of pipe-cap can be found in any case by adding 1.24 meters to elevation of top of bolt.]

P. R. P. 1. At west end of Iron Mountain Railroad Bridge at Fulton, Ark.; between track and south wing-wall of abutment and about 10 feet back of bridge seat. Reference points are the following: No. 1, bridge plate at west end of north truss of bridge, azimuth from P. R. P. is 200° 08′; No. 2, bridge plate at west end of south truss of bridge, azimuth from P. R. P. is 231° 05′; No. 3, west end of south wing-wall of abutment, azimuth from P. R. P. is 295° 22′.

P. R. P. 2. Right bank, on an azimuth of 328° 27′ from P. R. P. No. 1, and at a distance of 1,342 feet. It is near the river and about opposite lower end of small field on right bank. Three small cottonwoods between P. R. P. and field are blazed.

P. R. P 3. On Smith's plantation; 900 feet from river and 2,000 feet below gin. In field 2 feet from fence. Reference trees: No. 1 is a 5-foot cottonwood, on an azimuth of 110° from P. R. P., and 32 feet distant; No. 2, 2-foot sycamore 251°, 53 feet; No. 3, 2-foot cypress, 313°, 20 feet. Elevation, 80.55.

P. R. P 4. On Ferguson's plantation; left bank; about 1,400 feet below gin in deadening; 2 feet from fence, and about 400 feet from river bank. Reference trees: No. 1, 2-foot cottonwood, 130°, 46 feet; No. 2, 1-foot sycamore, 245°, 37 feet; No. 3, 1-foot sycamore 317°, 27 feet. Elevation, 80.15.

P. R. P. 5. On right bank, about 1,050 feet below clearing at lower end of Dr. Mill's plantation, and about 530 feet from river, and 380 feet back of wagon road passing in front of clearing. Reference trees: No. 1, box-elder, 334°, 17 feet; No. 2, 1-foot mulberry, 172°, 19 feet; No. 3, 2-foot cottonwood, 102°, 28 feet. Elevation, 79.78.

P. R. P. 6. On right bank; 3,600 feet below Sim's Landing; 2,000 feet above Red Lake, and 400 feet from river. It is about opposite lower end of Henry Gopp's plantation. Elevation, 79.32.

P. R. P. 7. On right bank; inside back levee near lower end of Wood's and Thaxler's plantation. References: No. 1, bend in levee, 102°, 10 feet; No. 2, 1 foot cottonwood, 142°, 17 feet; No. 3, 1-foot cottonwood, 161°, 25 feet. Elevation, 77.80.

P. R. P. 8. On right bank; on levee at upper end of Pearson's plantation; 1,500 feet from river and 600 feet back from lower end of lake. Elevation, 77.00.

P. R. P. 9. Right bank; on levee at lower end of Pearson's plantation; near where levee enters woods. Elevation, 76.24.

P. R. P. 10. Right bank; at lower end of plantation, owned by heirs of Merriman, Murphy; in northeast corner of garden inclosure. References: No. 1, edge of Candler Lake, 291°, 39 feet; No. 2, 3-foot pin oak, 2°, 100 feet; No. 3, 3-foot red oak, 223°, 90 feet; No. 4, southeast corner of cabin, 149°, 60 feet.

P. R. P. 11. Right bank; on Dr. P. H. Candler's place, about 1 mile below plantation house; 2,800 feet from river and 3 feet north of crown of back levee. Reference trees: No. 1, 1½-foot elm, south side of levee, 7 feet; No. 2, 1-foot elm, north side of levee, 220° (about), 4 feet; No. 3, 2-foot elm, north side of levee, 290° (about), 14 feet.

P. R. P. 12. Left bank; on Armour's plantation, about 1,500 feet above gin, and on crown of front levee. Reference trees: No. 1, 1½-foot cottonwood, 343°, 57 feet; No. 2, 1-foot cottonwood, 14°, 53 feet; No. 3, 1-foot elm, 63°, 29 feet. Elevation, 73.62.

P. R. P. 13. Right bank; near upper end of California plantation; 66 feet west of lower end of Nigger Lake; 32 feet back of levee, and 28 feet north of slough. References: No. 2, angle in levee, 287°, 51 feet; No. 3, angle in levee, 182°, 70 feet; No. 7, 2-foot cottonwood, 211°, 127 feet.

P. R. P. 14. Left bank; about 800 feet back of Jordan Landing and 500 feet south of Terrell Bayou; at corner of levee between Terrell's and Dixon's plantation. References: No. 1, 4-foot cottonwood, 147°, 200 feet; No. 2, southeast corner of cabin, 178°, 224 feet; No. 3, northeast corner of cabin, 75°, 40′, 670 feet. Elevation, 72.07.

P. R. P. 15. Left bank; on Conway's or Long Prairie plantation; about 1,300 feet back of Conway's Landing; at intersection of two levees. References: No. 1, levee intersection, 82° 45′, 764 feet; No. 2, northeast corner of cabin, 42° 55′, 188 feet. Elevation, 71.90.

P. R. P. 16. Left bank; on Smith's Bend plantation; at edge of woods; 900 feet from river at upper end of bend; 1,000 feet from river at lower end of bend, and 2,000 feet above point where levee crosses neck. References: No. 1, southeast corner of cabin, 163° 20′, 578 feet; No. 2, 1-foot cottonwood, 177° 60′, 13 feet; No. 3, cottonwood (in woods), 276° 00′, 24 feet. Elevation: 70.36.

P. R. P. 17. Left bank; in woods, about half-way between river and Anthony's Lake, and 900 feet below north end of lake. Reference trees: No. 1, 3-foot sweet gum, 327°, 57 feet; No. 2, 1-foot ash, 35°, 24 feet; No. 3, 1-foot box-elder, 178°, 27 feet. Elevation: 69.21.

P. R. P. 18. Left bank; about 1 mile above mouth of Sulphur River; 200 feet from river, and 115 feet back of road; about 450 feet above small cabin. It is in middle of "chain line cut" through the woods. Reference trees: No. 1, 1½-foot cottonwood, 255°, 6 feet; No. 2, 1½-foot cottonwood, 174°, 36 feet; No. 3, 1-foot cottonwood, 132°, 23 feet; No. 4, 1-foot cottonwood, 87°, 33 feet. Elevation: 70.17.

P. R. P. 19. Right bank; 3 miles below Spring Bank; at foot of Digg's Bluff, which is the first point where river strikes the hills below Spring Bank. References: No. 1, 3-foot white oak, 220° (about), 40 feet; No. 2, 1-foot red oak, 180° (about), 70 feet; No. 3, southeast corner of old warehouse, 140° (about), 35 feet.

P. R. P. 20. Left bank; 3¼ miles below Digg's Bluff; about one-half mile below point where river turns sharply to the left; 137 feet from river, and in heavy timber. Reference trees: No. 1, 5-foot cottonwood, 81°, 6 feet; No. 2, 3-foot cottonwood, 170°, 7 feet; No. 3, 1-foot sweet-gum, 351°, 21 feet. Elevation: 71.39.

P. R. P. 21. Right bank; on side of bluff, about 500 feet above the Arkansas and Louisiana State-line; 30 feet from foot of bluff and 75 feet from bank of bayou, back of Hunt's plantation. Reference trees: No. 1, 1½-foot ash, 288°, 24 feet; No. 2, 2-foot cottonwood standing by fence near foot of bluff, 260°, 64 feet; No. 3, 1-foot red oak, 205°, 20 feet; No. 4, 1-foot hickory, 61°, 28 feet. Elevation: 72.05.

P. R. P. 22. Right bank; 90 feet south of south bank of Bargetown Slough, and 900 feet from mouth of same; in old chain-line cut. References: No. 1, 1½-foot cottonwood, 151°, 25 feet; No. 2, 1-foot cottonwood, 3°, 13 feet; No. 3, 1½-foot cottonwood, 281°, 37 feet. Elevation: 68.62.

P. R. P. 23. Left bank; at head of Boone's Bend; opposite where neck of point is most narrow; 128 feet back from river; in old chain-line cut: Reference trees: No. 1, 1½-foot cottonwood, 316°, 26 feet; No. 2, 1-foot cottonwood, 169°, 62 feet; No. 3, 1-foot cottonwood, 64°, 26 feet. Elevation: 68.24.

P. R. P. 24. Left bank; 80 feet from south side of Alban's Canal No. 1, and about 450 feet from river. Reference trees: No. 1, 1-foot willow, 151°, 5 feet; No. 2, 1½-foot cottonwood, 343°, 7 feet; No. 3, 1-foot cottonwood, 247°, 13 feet.

P. R. P. 25. Left bank; 160 feet below Poslen Bayou, and 250 feet from river; at upper back corner of old clearing. Reference trees: No. 1, 1-foot ash, 120°, 23 feet; No. 2, 1-foot ash, 232°, 6 feet; No. 3, 2-foot cottonwood, 189°, 63 feet. Elevation: 66.77.

P. R. P. 26. Left bank; between Red River and Dutch Jan's Lake; 320 feet above Fuller's inlet, 450 feet from river, and 150 feet from bank of Jan's Lake; in old chain-line cut. Reference trees: No. 1, 1-foot sycamore, 70°, 24 feet; No. 2, 1-foot sycamore, 148°, 20 feet; No. 3, 2-foot cottonwood, 262°, 17 feet; No. 4, 2-foot cottonwood, 328°, 17 feet.

P. R. P. 27. On top of bluff about 2,400 feet above Gilmer Landing, and just below mouth of Fuller's outlet. Reference trees: No. 1, 1½-foot red oak, 311°, 10 feet; No. 2, 1-foot hickory, 204°, 22 feet; No. 3, ½-foot black jack, 161°, 43 feet.

P. R. P. 28. On back levee, between Peru Plantation and Dooley's Bayou; about 2,000 feet from river, 300 feet from bayou, and 6,000 feet below head of bayou. Reference trees: No. 1, 1½-foot cottonwood, 329°, 14 feet; No. 2, 1½-foot cottonwood, 273°, 21 feet; No. 3, 1½-foot cottonwood, 166°, 11 feet. Elevation: 65.77.

P. R. P. 28*a*. On back levee of Lake Home Plantation; 150 feet below bend in levee and 1,130 feet above fence running towards the river. Bench is 1,650 feet from river at a point about 1,000 feet above mouth of small bayou. It coincides with Chain Line Point E O, survey of 1886. Elevation: 63.94.

P. R. P. 29. About 1 mile above where river strikes Hurricane Bluffs, and seven-eighths miles above mouth of Old River. It is at foot of bluffs, opposite Martin and Hugh's plantation, and 80 feet from bank of Old River. Reference trees: No. 1, 3-foot cottonwood, 67°, 50 feet; No. 2, 3-foot red oak, 162°, 40 feet; No. 3, 3-foot pine, 302°, 30 feet.

P. R. P. 30. At foot of Hurricane Bluffs, about 100 feet from Red River and 500 feet below mouth of Old River. References: No. 1, old store-house 167°, 155 feet; No. 2, gum tree, 164°, 100 feet; No. 3, black gum, 15°, 80 feet. Elevation: 65.10.

P. R. P. 31. On Colonel Vane's plantation, at intersection of fence on west side of public road, with fence on north side of stable-yard, and 3 feet east of timber supporting southeast corner of wind-mill tower. Elevation: 61.56.

P. R. P. 32. On plantation of T. J. Vance; in front of plantation house, and on top of levee; about 420 feet above Benoit's Bayou. References: No. 1, southwest corner dwelling-house, 265° 40′, 212 feet; No. 2, large cottonwood, 193° 43′; No. 3, large cottonwood, 224° 45′; No. 4, large cottonwood, 281° 37′. Elevation: 58.79.

P. R. P. 33. In southwest corner of yard around cabin on estate of M. Barr, and just above Barr's Ferry; about 400 feet from river; opposite J. W. Jeter's plantation. Elevation: 59.48.

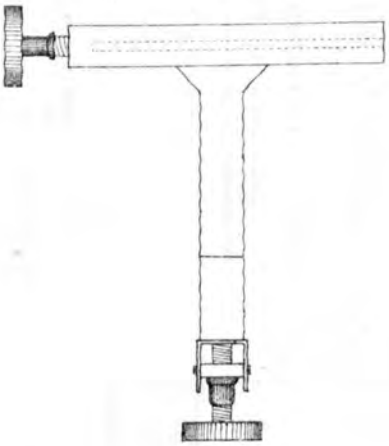
P. R. P. 34. Right bank; at northeast corner of cabin on E. B. Herndon's plantation, and nearly opposite line between plantations of Mrs. Carmouche and Pat. Cash.

P. R. P. 35. In southwest corner of yard of residence of Mrs. M. D. C. Cane, at Bossier City, opposite Shreveport. Elevation: 58.21.

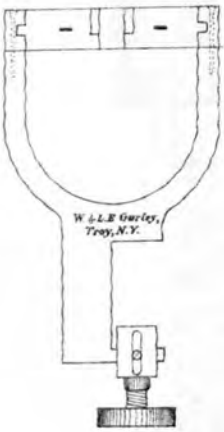
Plate No. 1.

Vertical Projection,

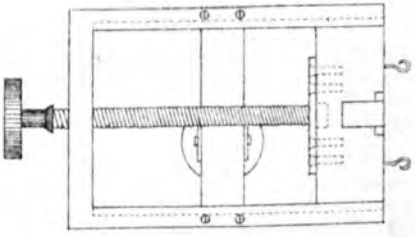
Side.

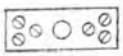


End.



Horizontal Projection.





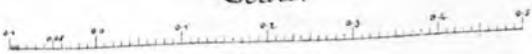
Vertical Section.

Tension Balance
for
Base Measuring Tapes,
Red River Survey.

Designed under direction of Capt J. N. Willard, U. S. Army,
by
N. M. Marshall, C. E.

February, 1889.

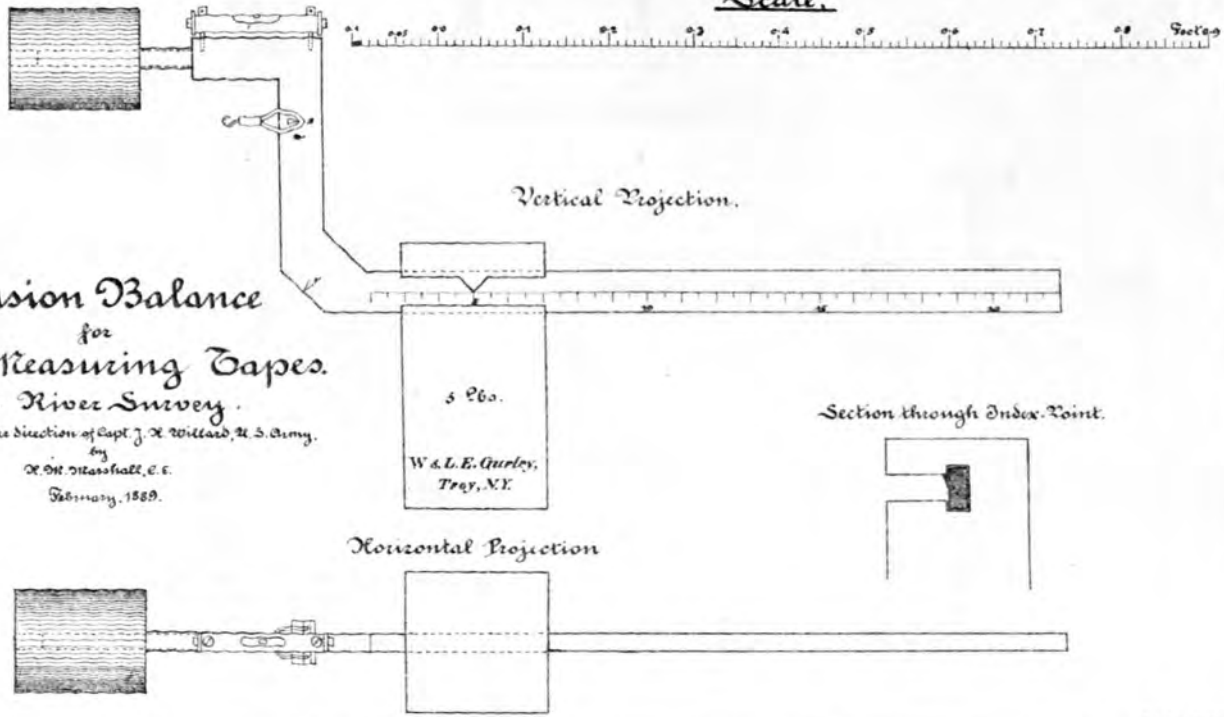
Scale.



Del. John Hlicke, C.E.

Photo-Lith. by A. HOEN & CO., Balto., Md.

Plate No. 2.



Vernier

for

Brass and Steel Measuring Tapes.

Designed for use on

Red River Survey

under direction of Capt. J. N. Willard, U.S. Army.

by

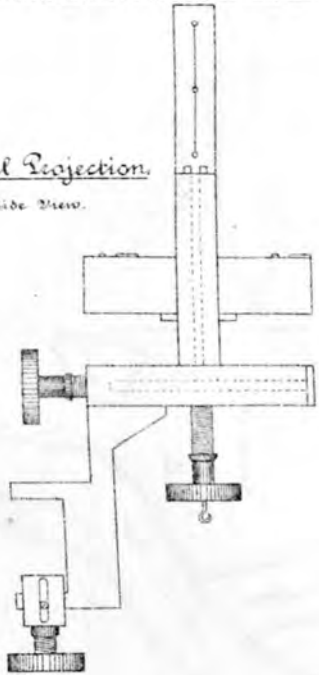
N. M. Macomb, C. E.

February, 1869.

Scale

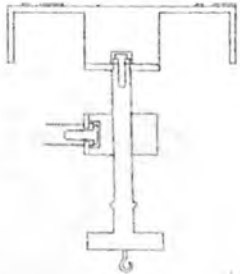
Vertical Projection.

Side View.



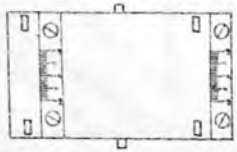
Vertical Section

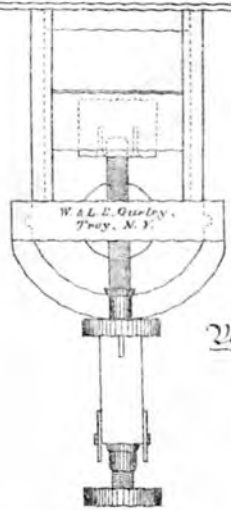
of vernier screw and stepping block



Horizontal Projection

of Vernier block.



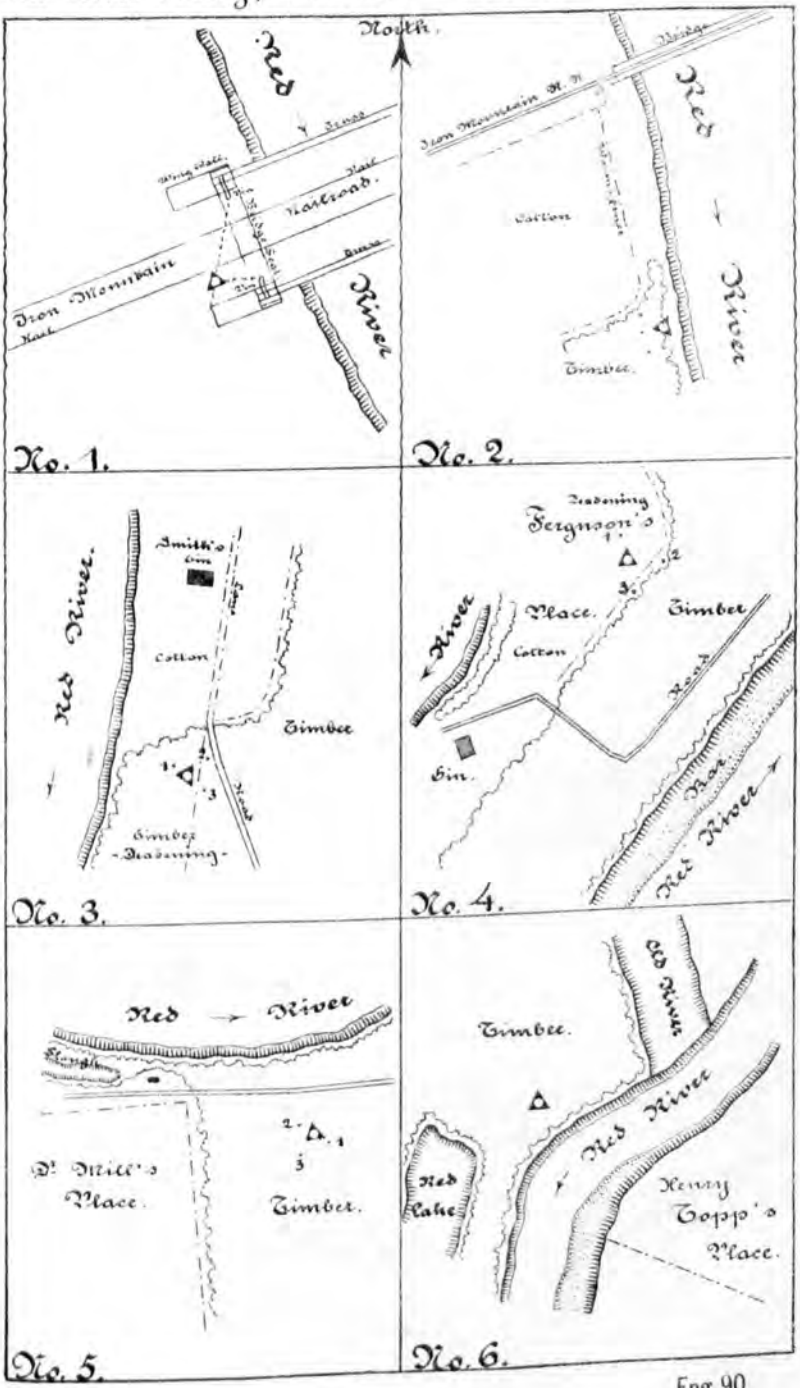


Vertical Projection.

End View.

Plate 3.

Red River Survey. - P.R.P. - Plate No. 4.



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Red River Survey—N. R. V.—Plate No. 5.

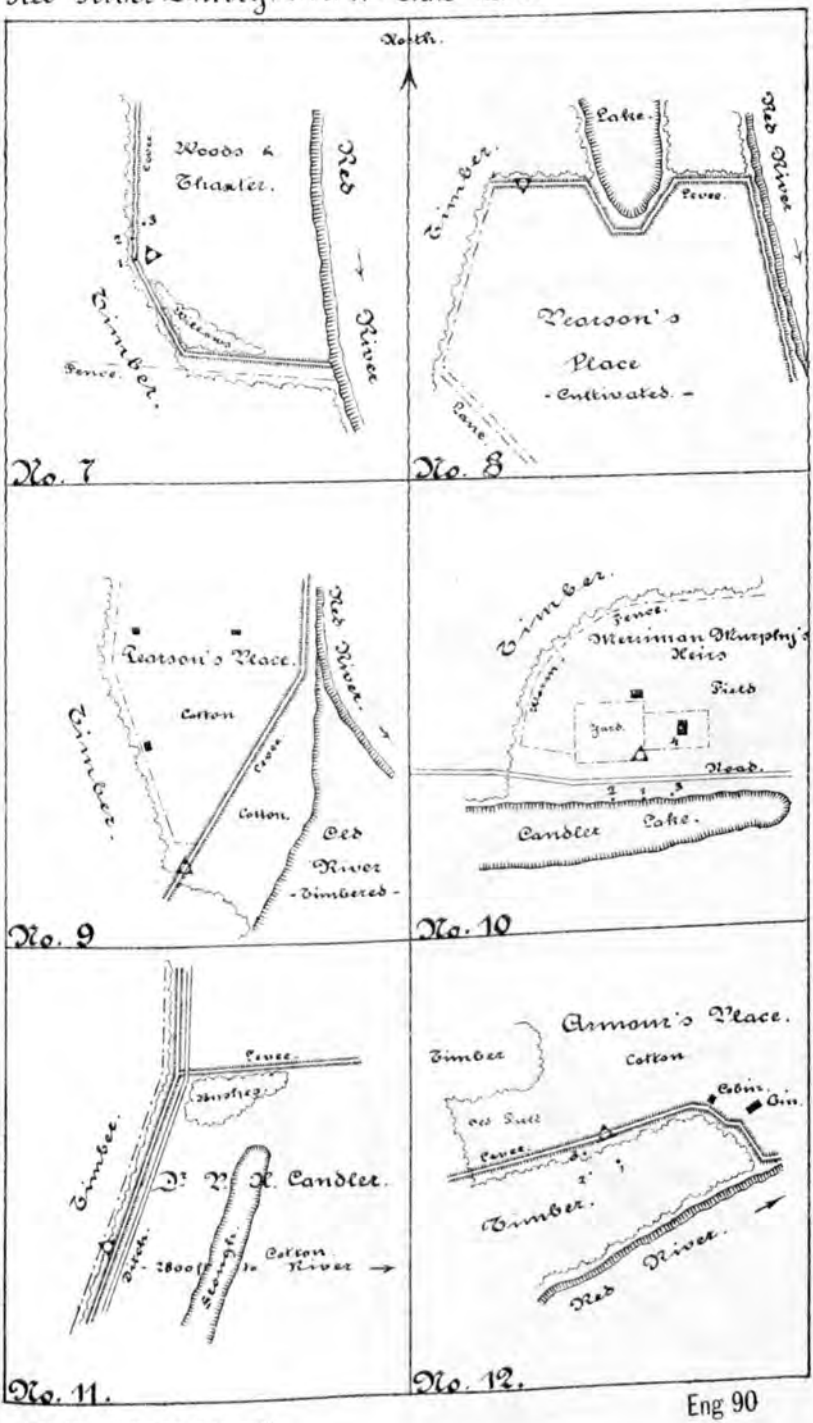

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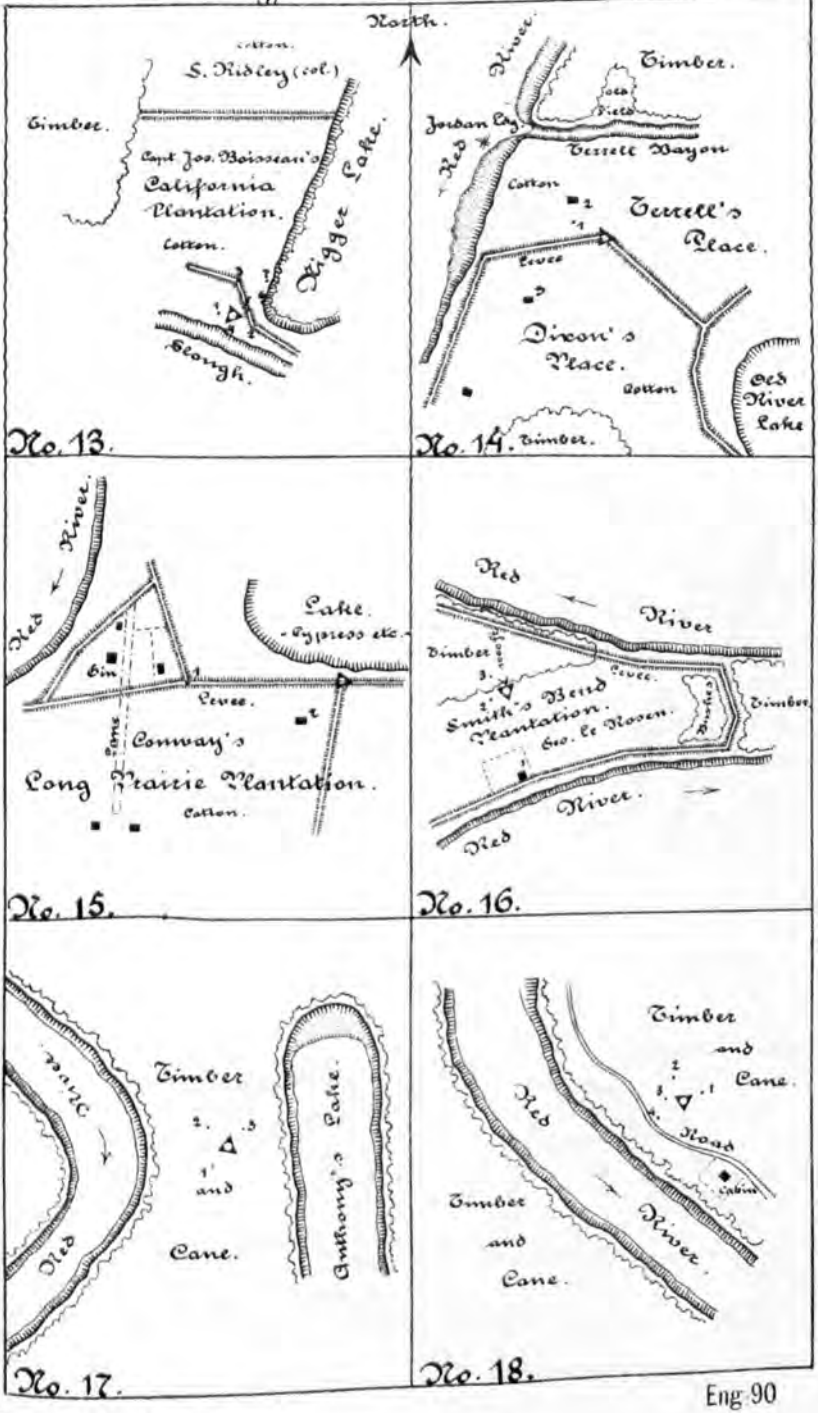
Photo-Lith. by A. HOEN & CO., Balto., Md.

Red River Survey - T. R. P. - Plate No. 6



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Red River Survey,- U.S.A.- Plate No. 7.

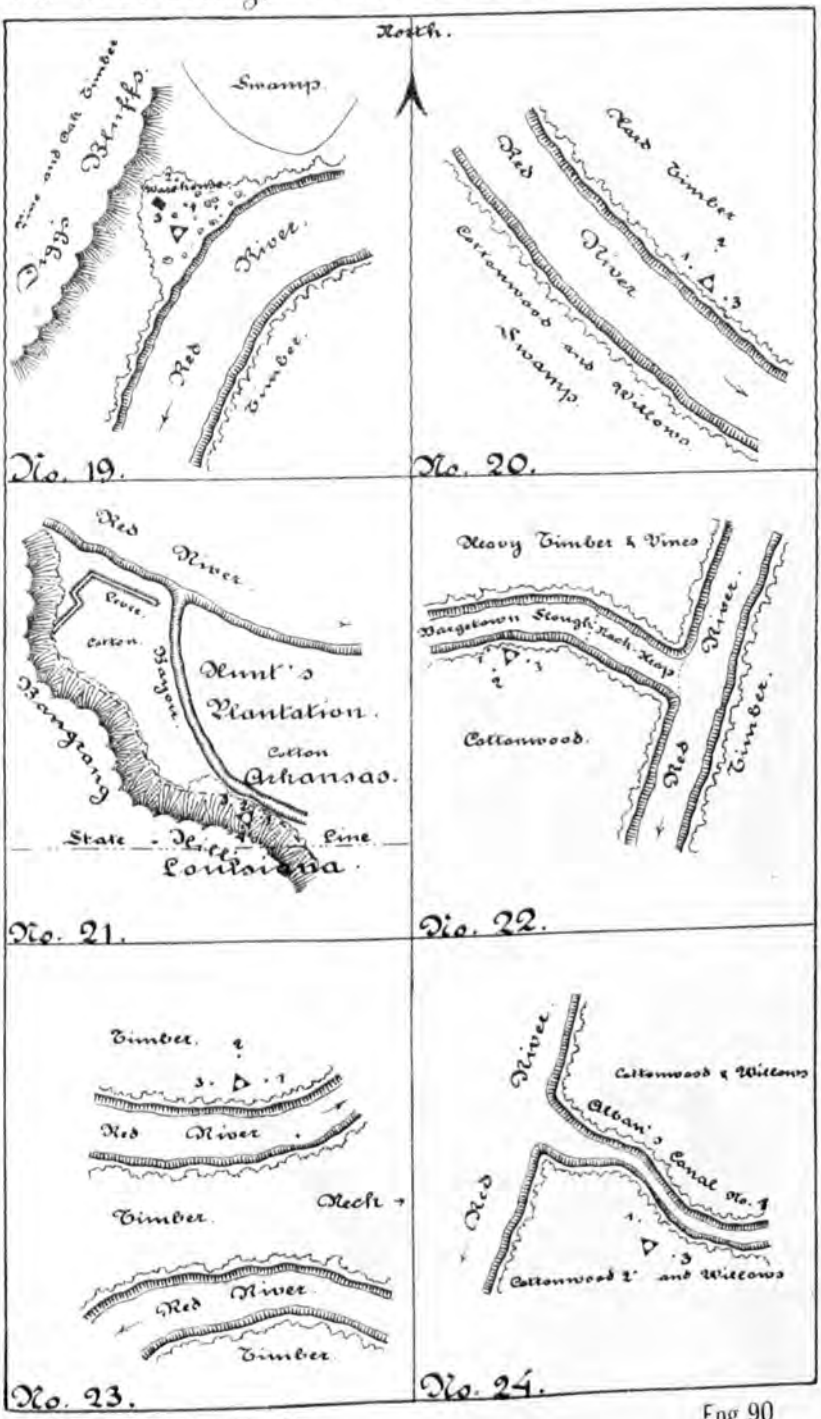


Photo-Lith. by A. HOEN & CO. Balto. Md.

Red River Survey, - N.R.N. - Plate No. 8.

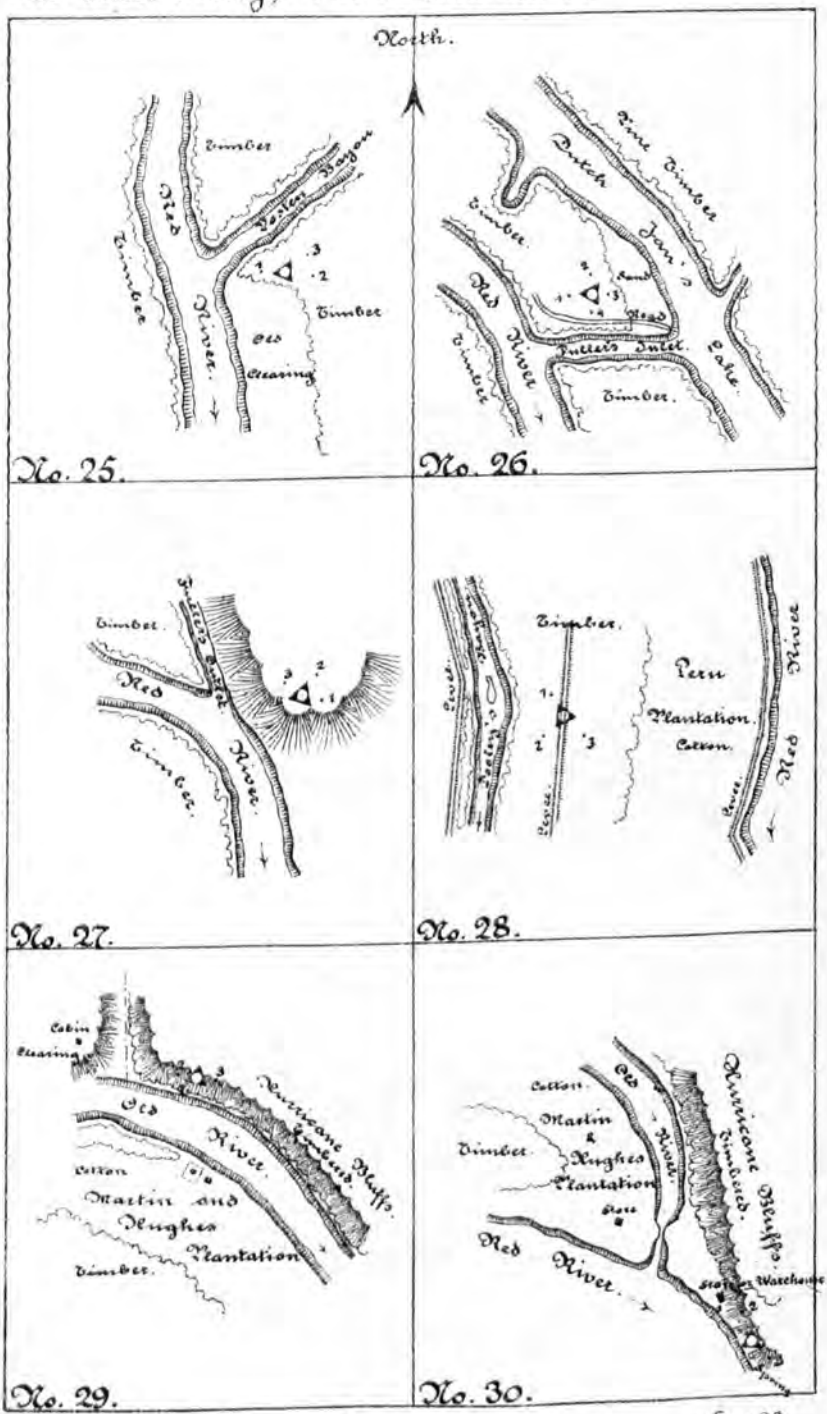
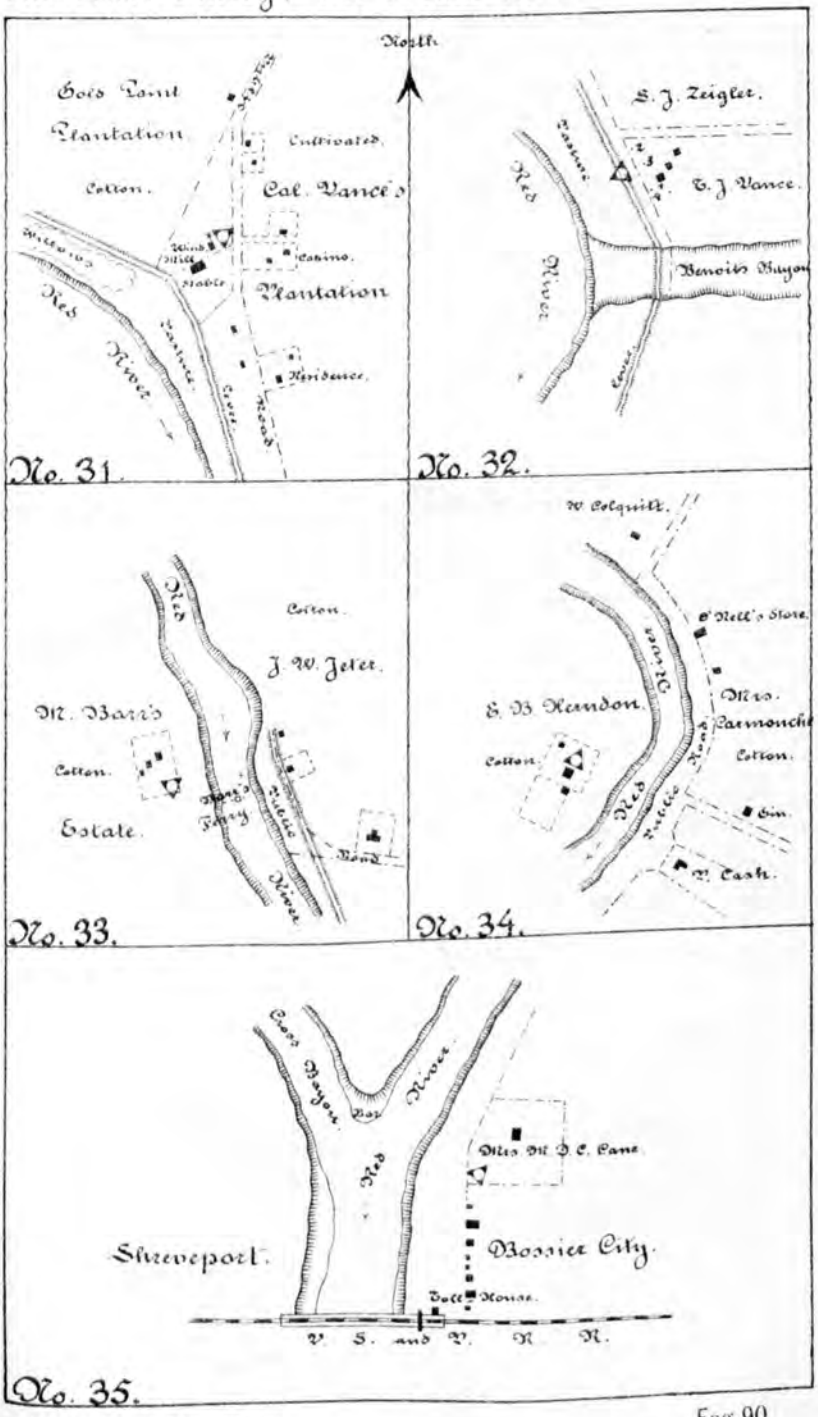


Photo-Lith. by A. HOEN & CO., Baltimore, MD.

Red River Survey.- U.S.N.- Plate No. 9.



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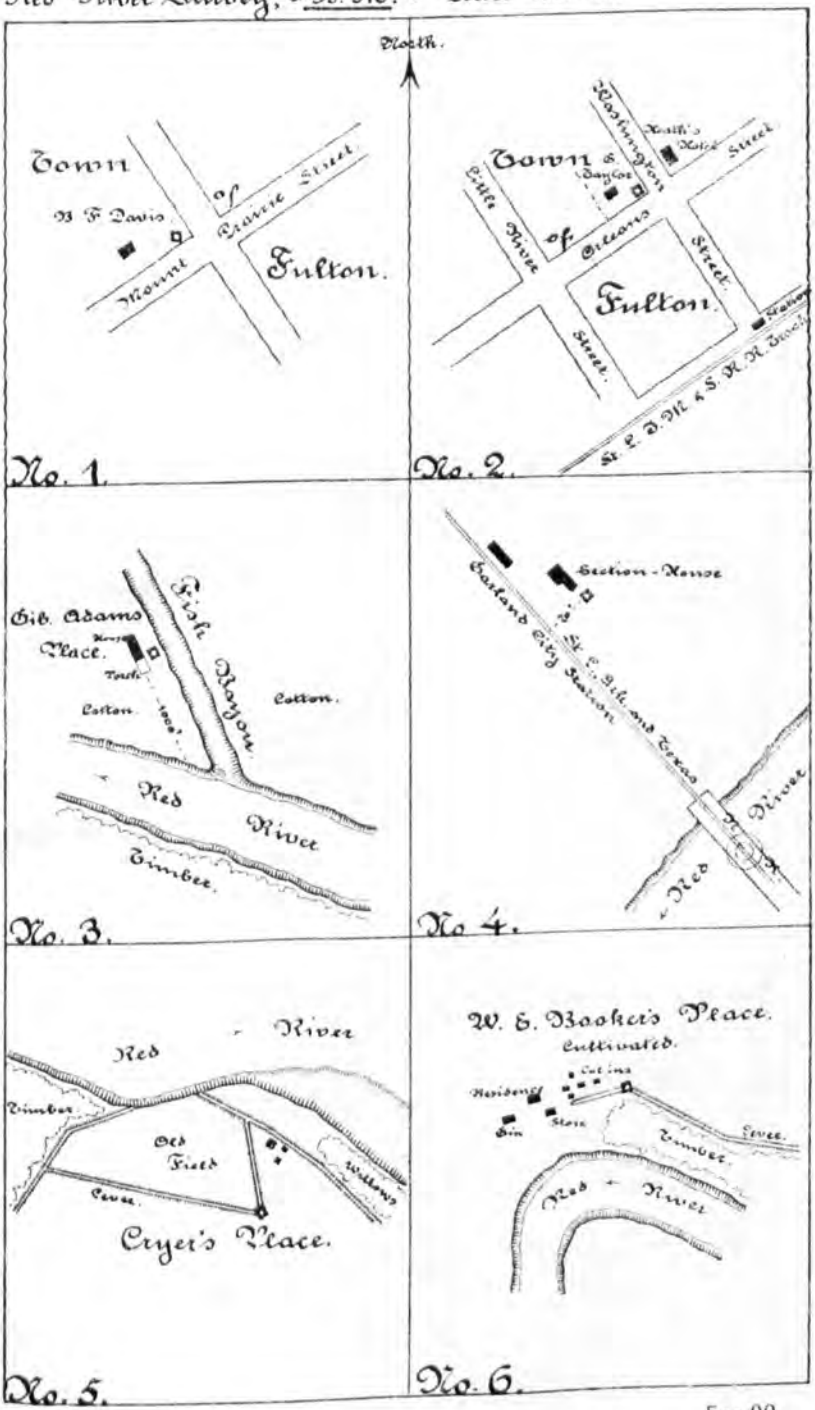
Red River Survey. - B. M. - Plate No. 10.



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Red River Survey.-B.M.-. Plate No. 11.

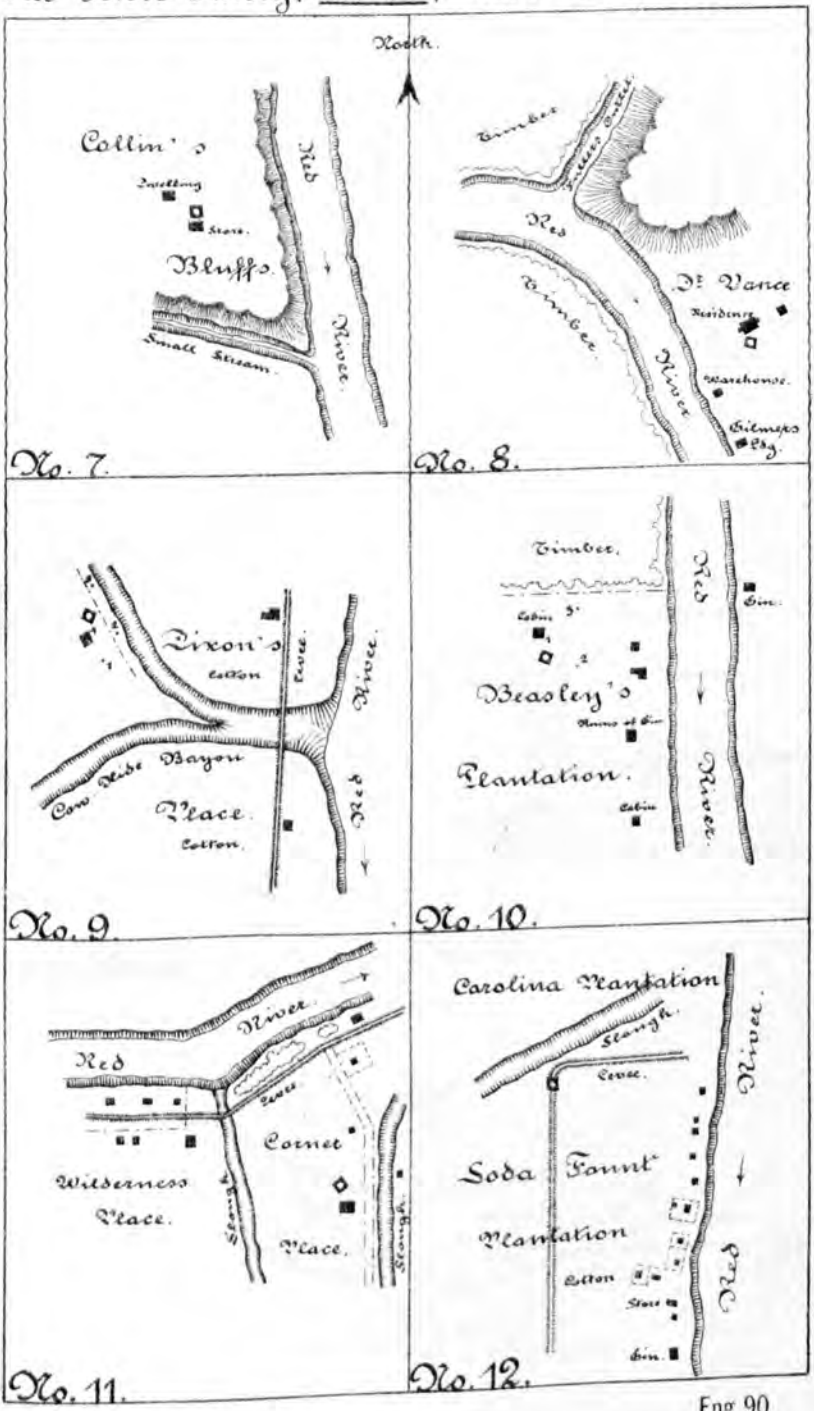

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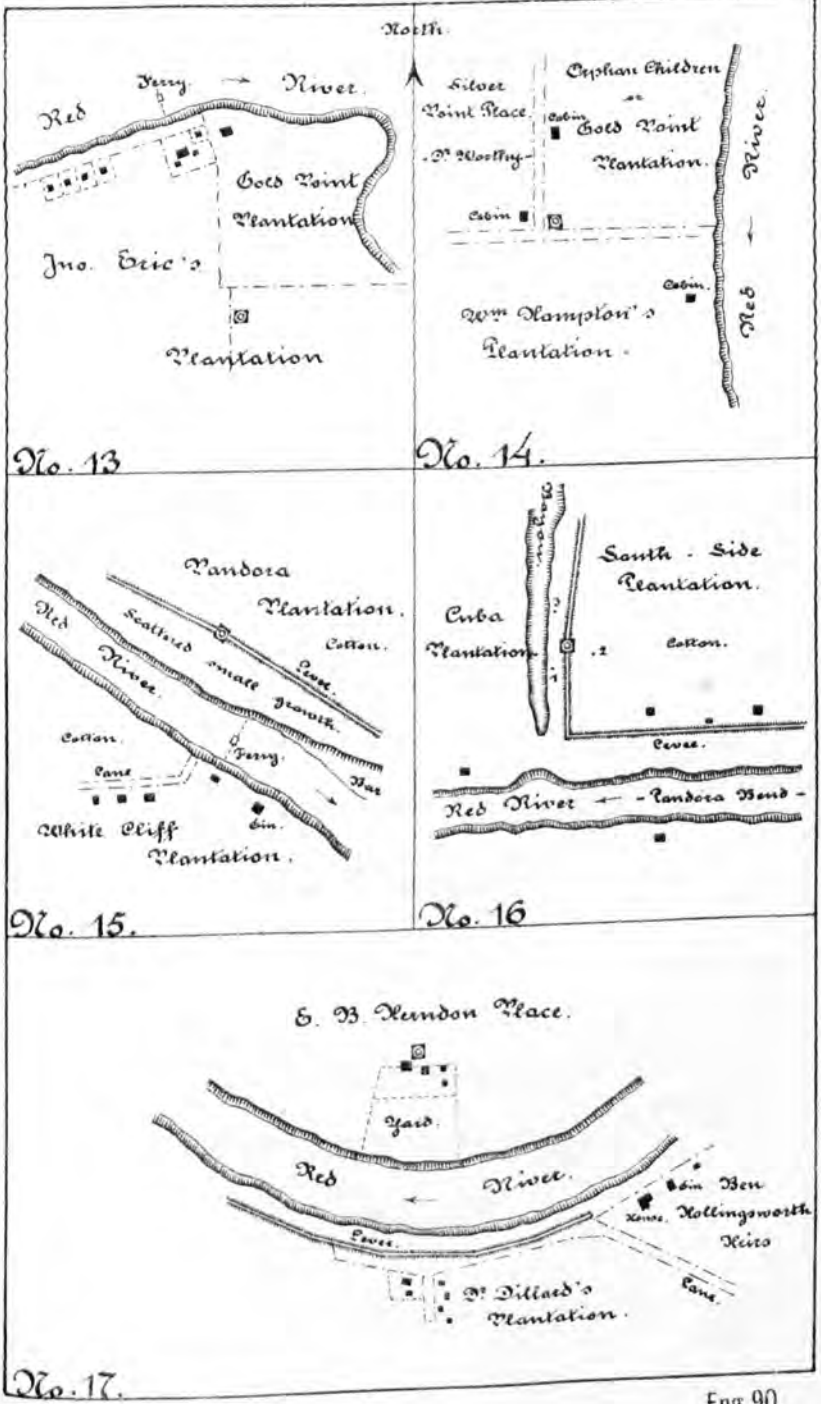
Photo-Lith. by A. HORN & CO., Balto., Md.

Red River Survey. – B. M. – Plate No. 12.



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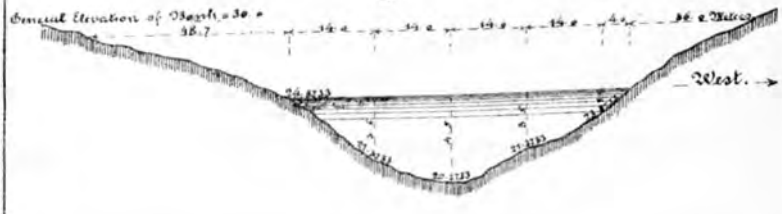
Red River Survey, — Cross-Sections of Tributaries. — Plate No. 13.

Lake One.

Tensas River.

Bayou Maçon.



Boeuf River.

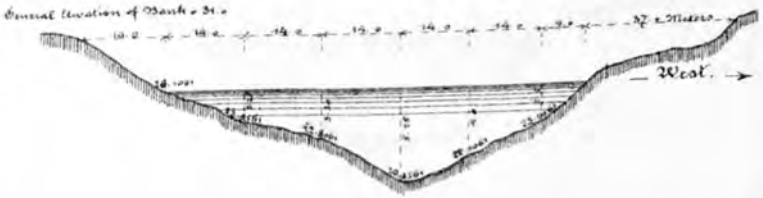


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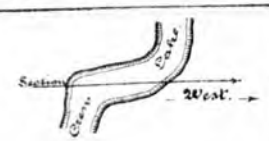
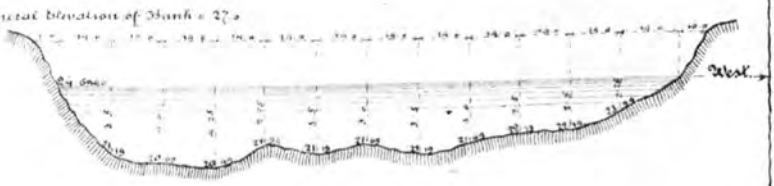
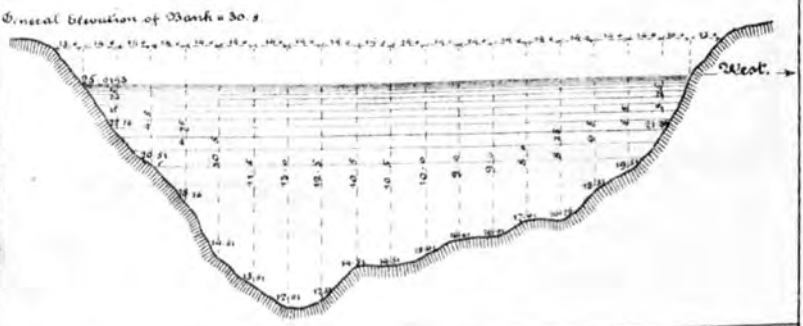
Photo-Lith. by A. HOEN & CO., Balto., Md.

Crew Lake.



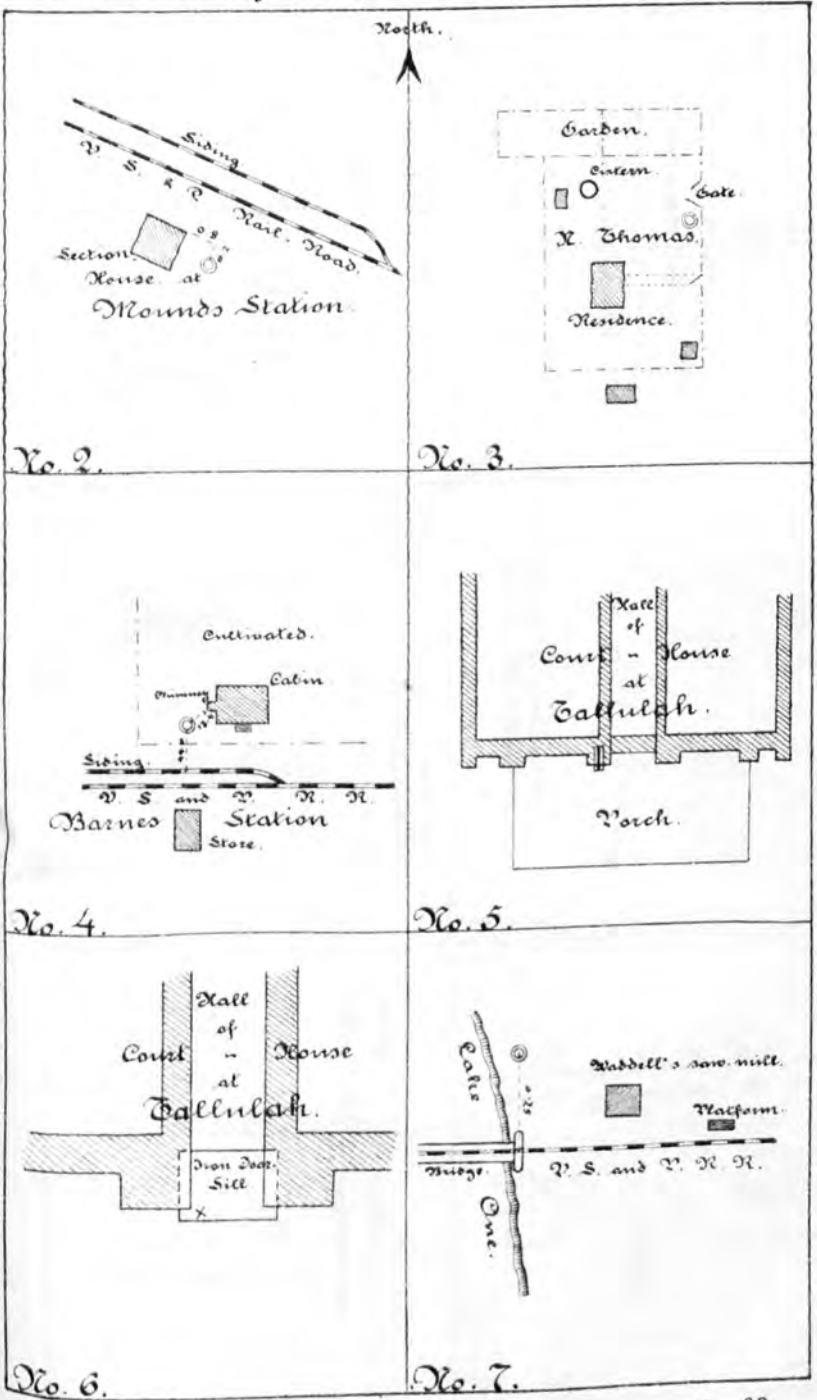


Ouachita River.



Bayou Dorcheat.

Photo-Lith. by A. HOEN & CO., Balto., Md.



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Red River Survey, - V. B. M. - Plate No. 16.

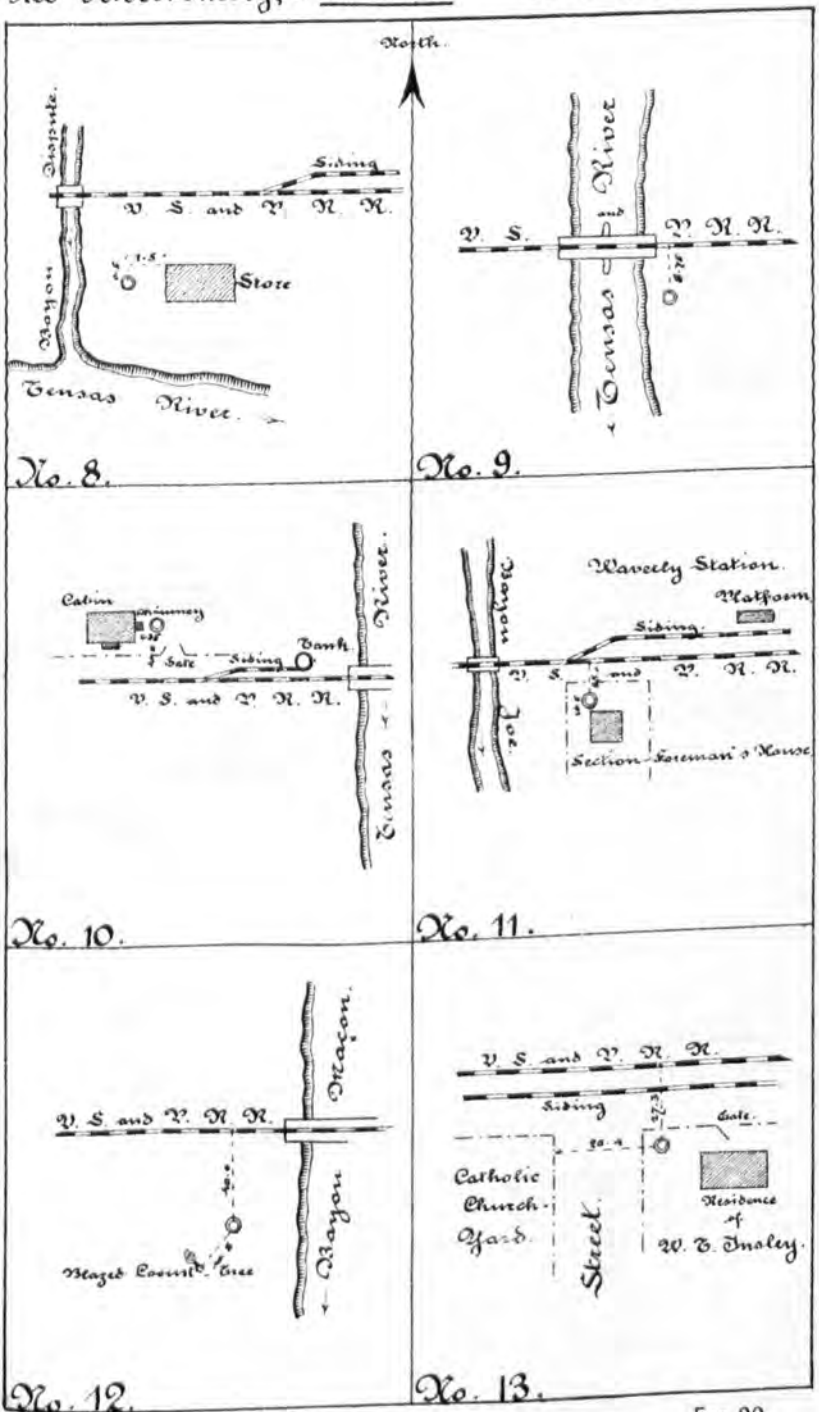

Photo-Lith. by A. HOEN & CO., Balto., Md.

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Red River Survey, - T. B. M. - Plate No. 17.

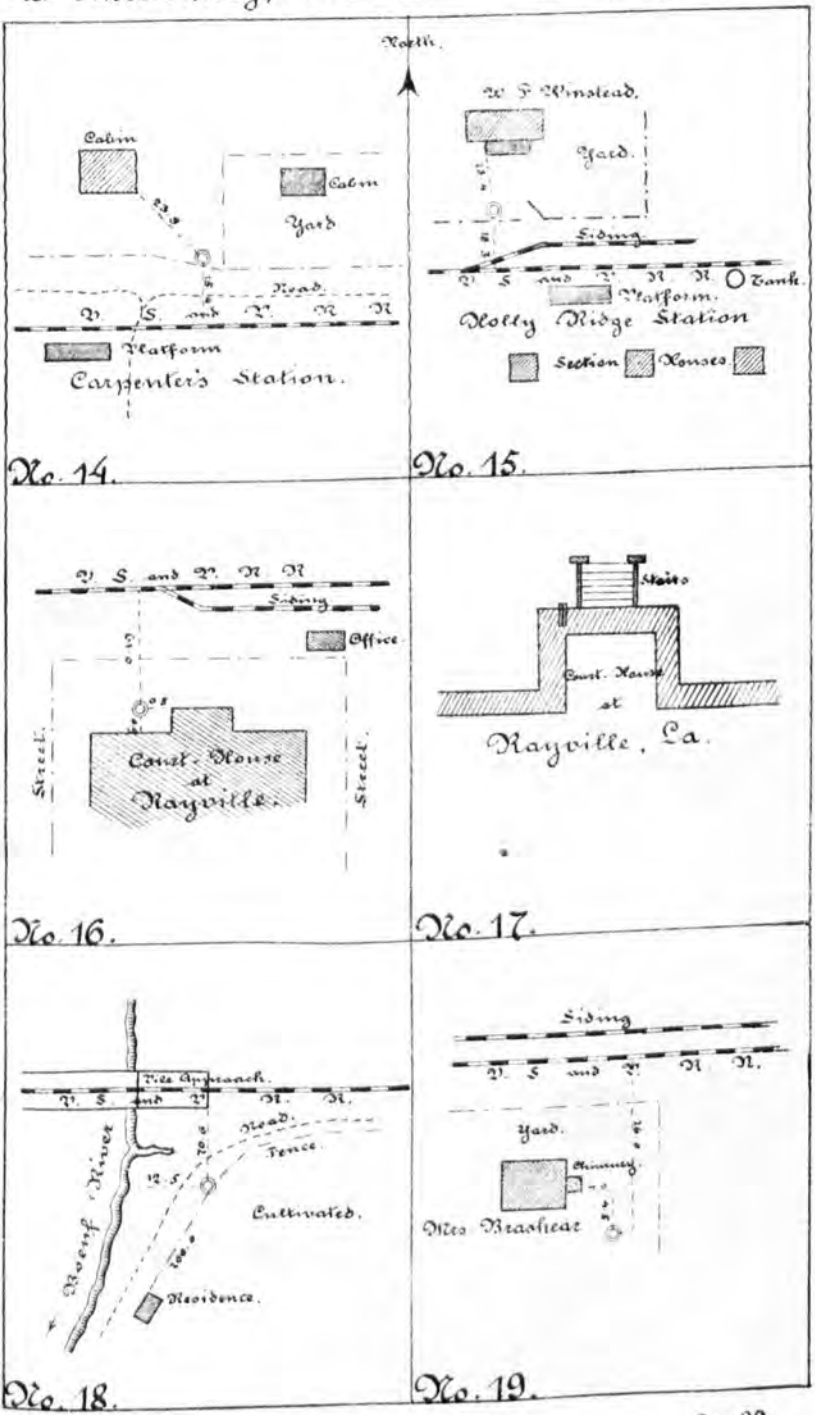

Photo-Lith. by A. HORN & CO. Balto. Md.

Red River Survey. ~ P. B. M. ~ Plate No. 18.

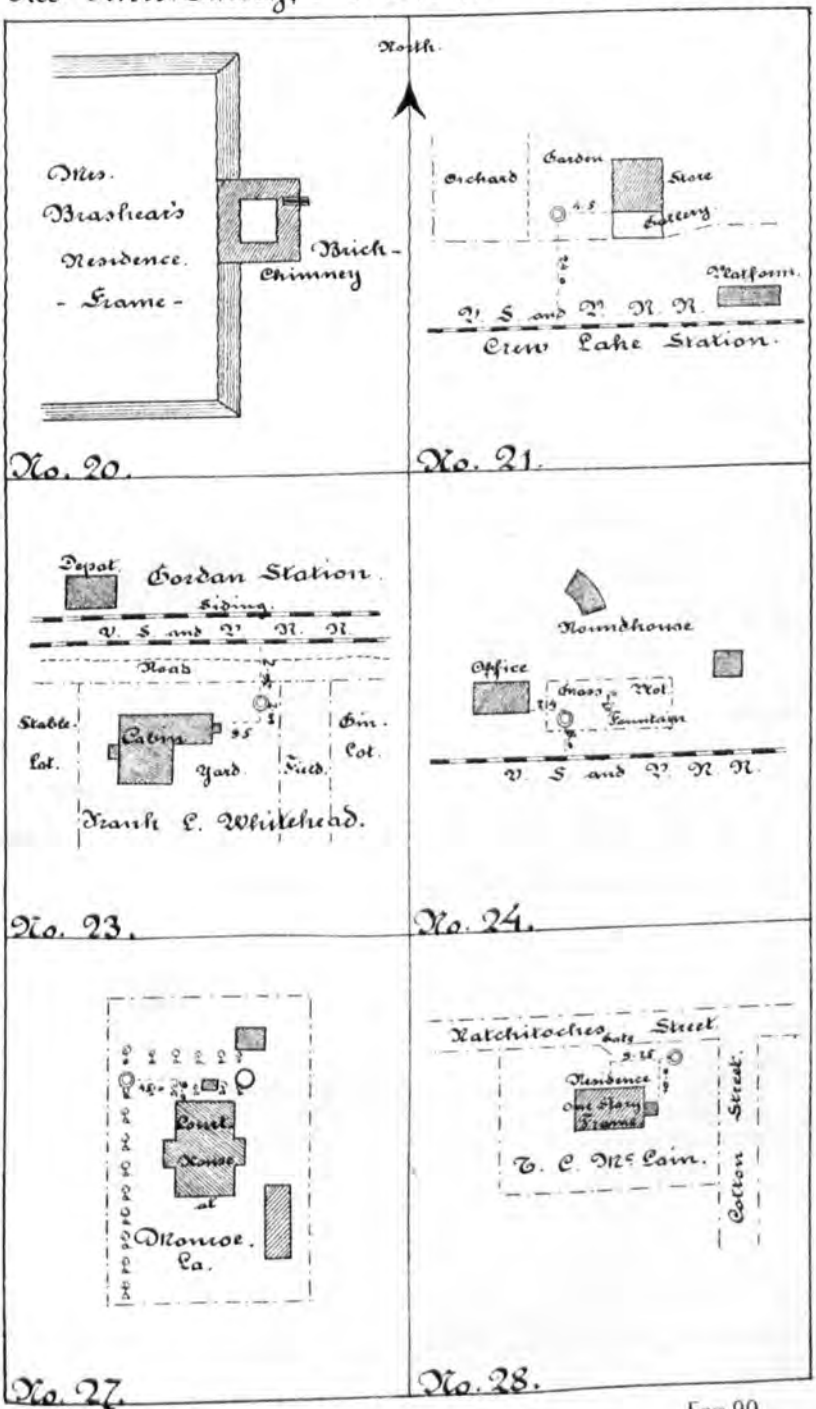

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Photo-Lith. by A. HOEN & CO., Balto., Md.

Red River Survey. - T. 13 N. - Plate No. 19.

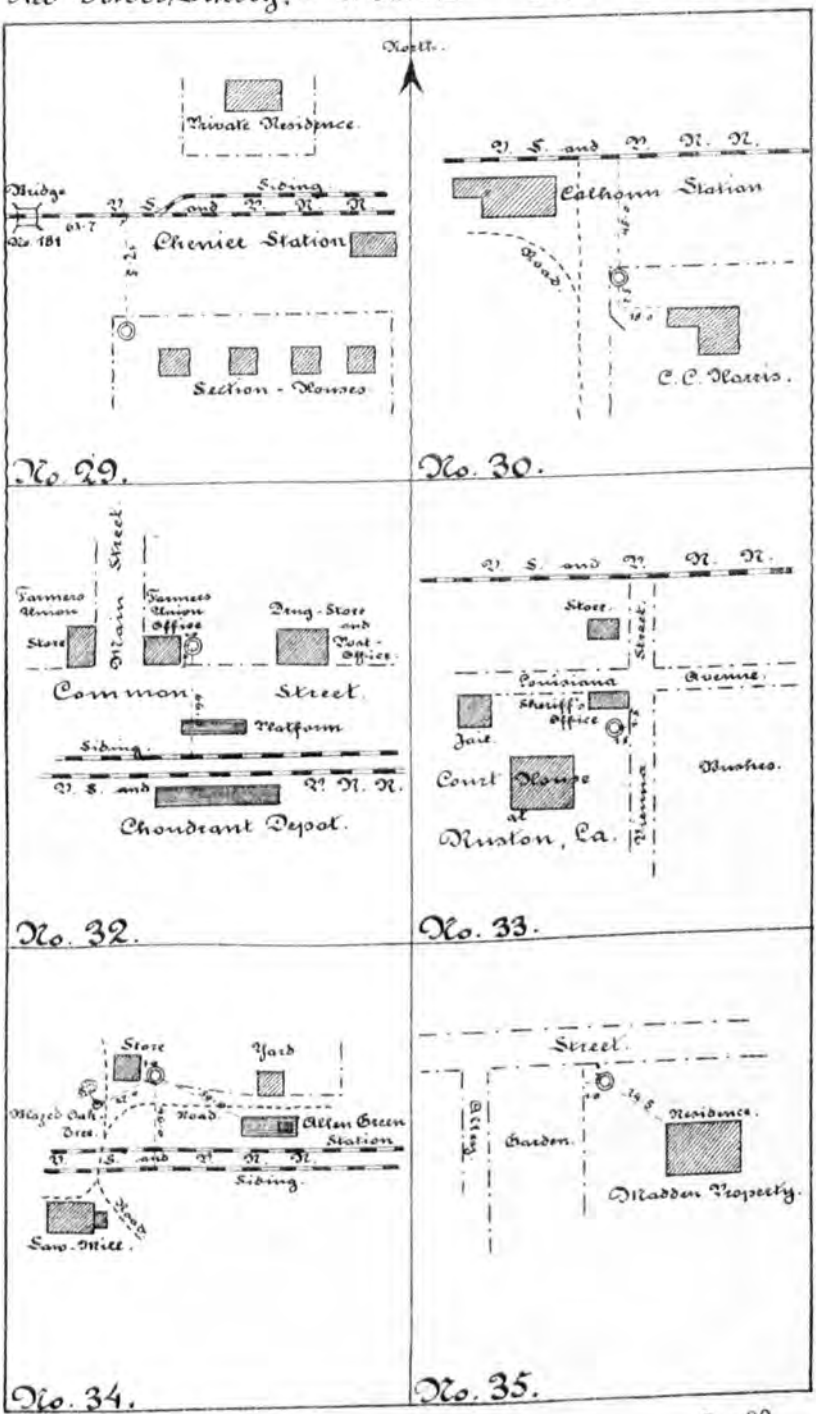


Photo-Lith. by A. HOEN & CO. Balto. Md.

Red River Survey. - V. D. M. - Plate No. 20.

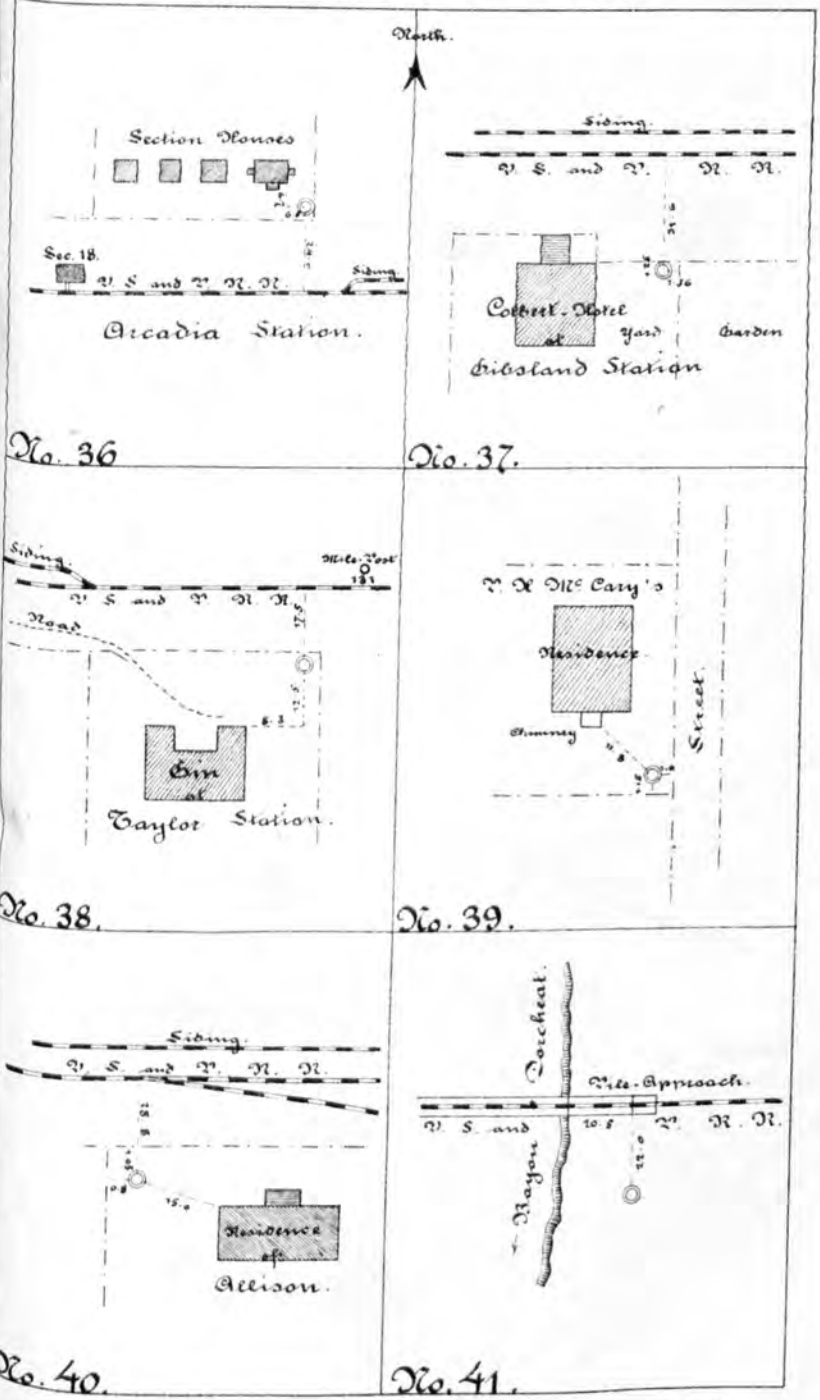


Photo-Lith. by A. HOEN & CO., Balto., Md

Red River Survey, - T. 13. N. - Plate No. 21.

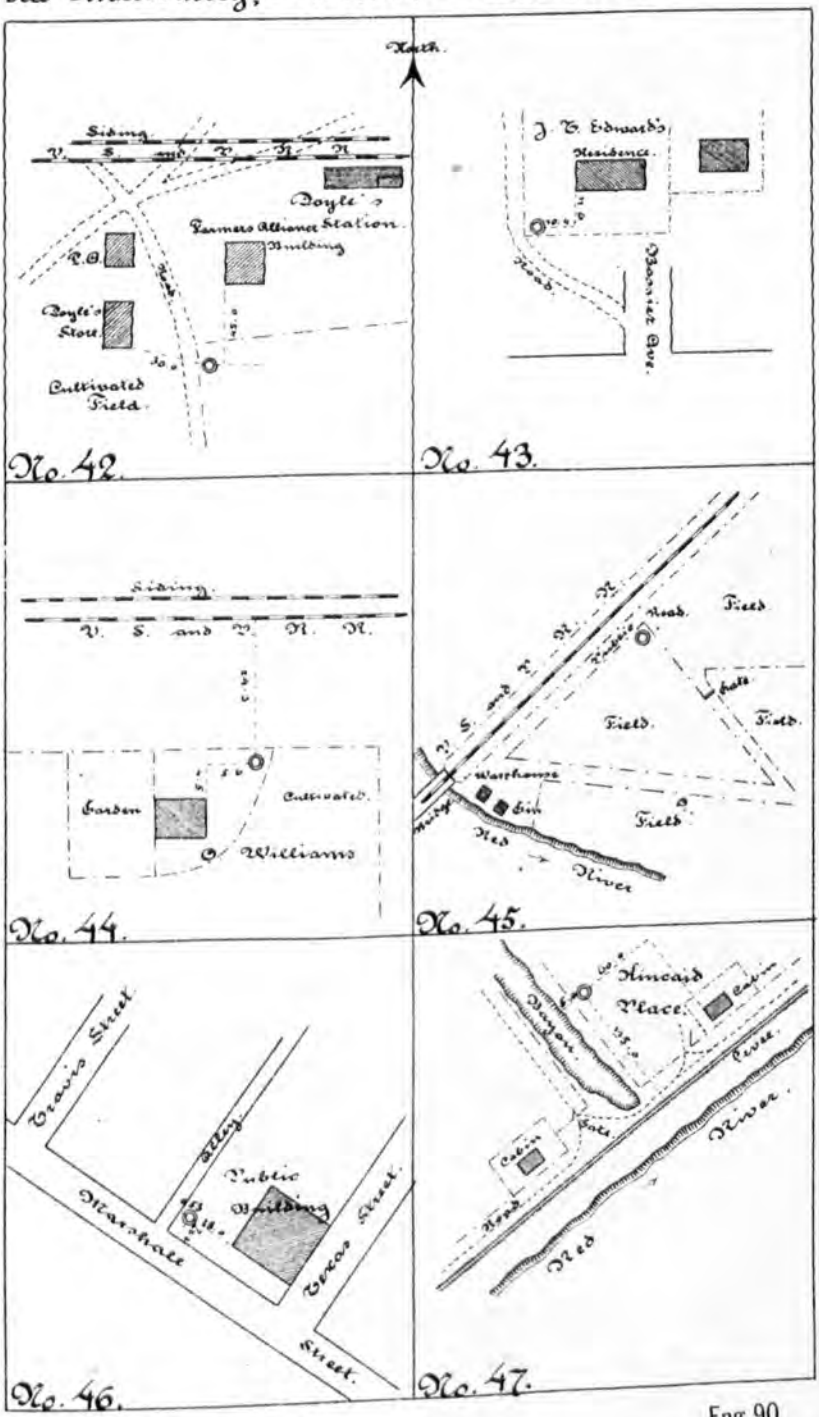
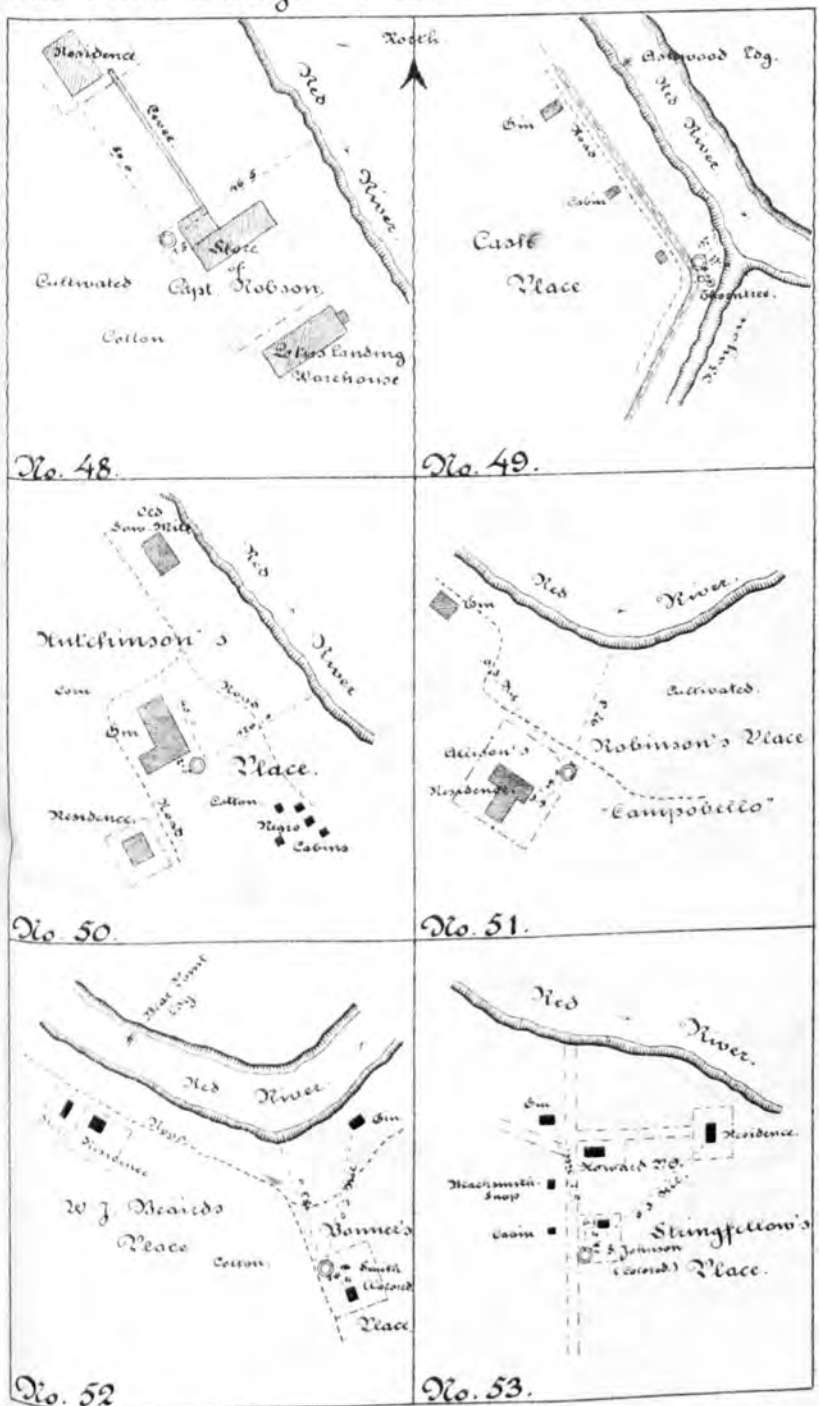


Photo-Lith. by A. HOEN & CO., Baltic., Md.

Red River Survey. - V. B. M. - Plate No 22.



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Red River Survey. - P. O. D. M. - Plate No. 23.

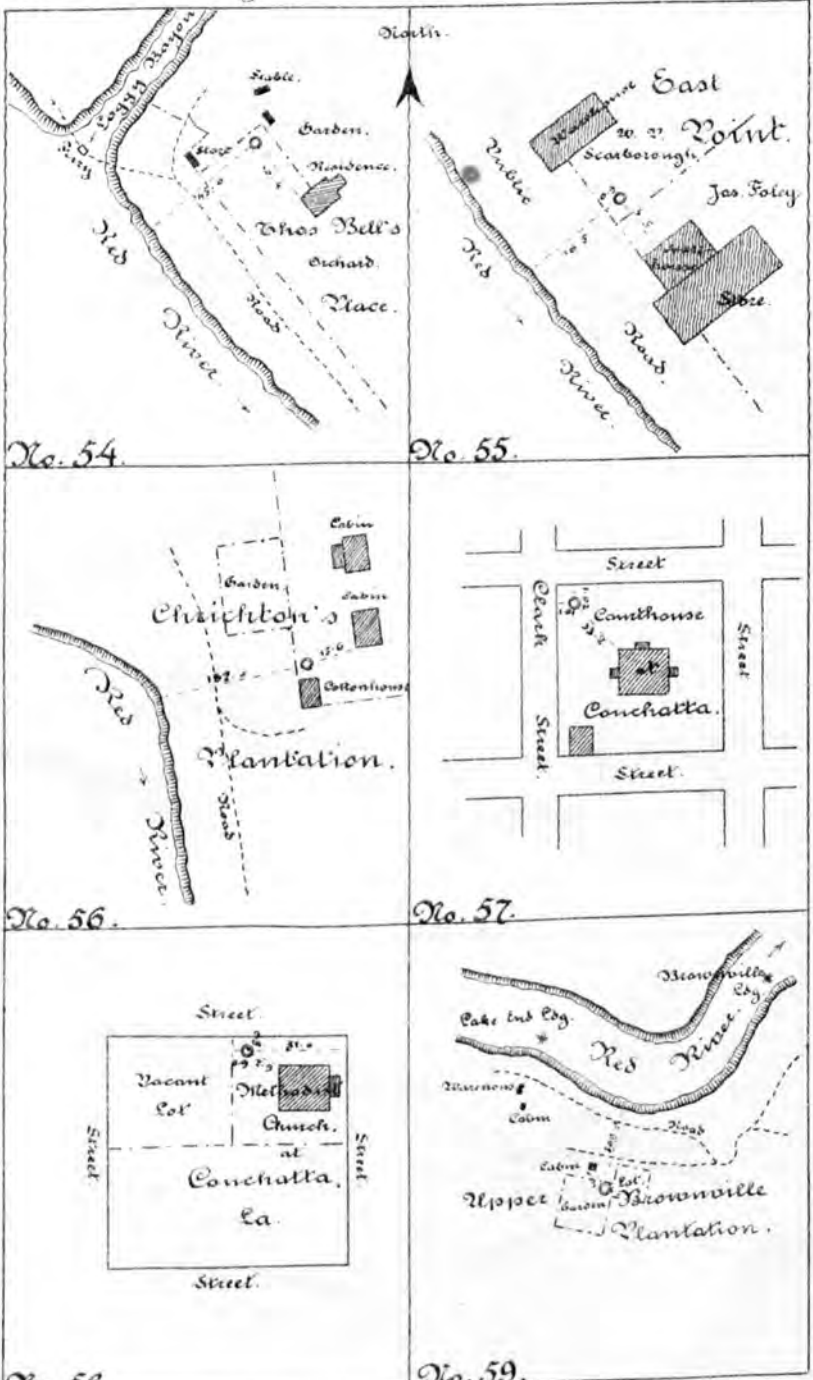

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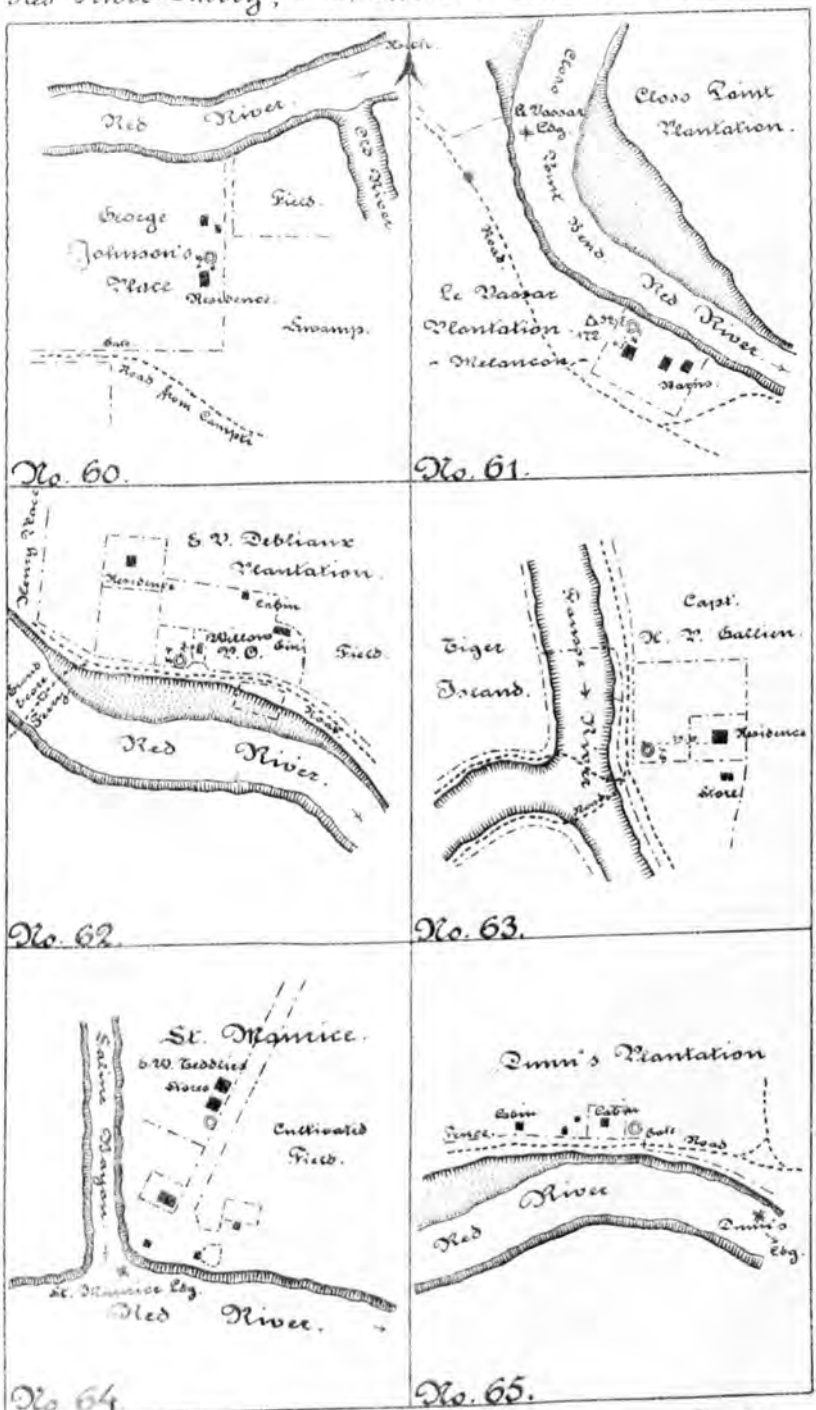
Photo-litho. by A. HORN & CO., Baltimore, Md.

Red River Survey, - P. B. M. - Plate No. 24.



Red River Survey. - T. 13 N. - Plate No. 25.

No. 66.

No. 67.

No. 68.

No. 69.

No. 70.

No. 71.

Photo-Lith. by A. HOEN & CO., Baltimore, Md.

Red River Survey, ~ P. B. M. ~ Plate No. 26.

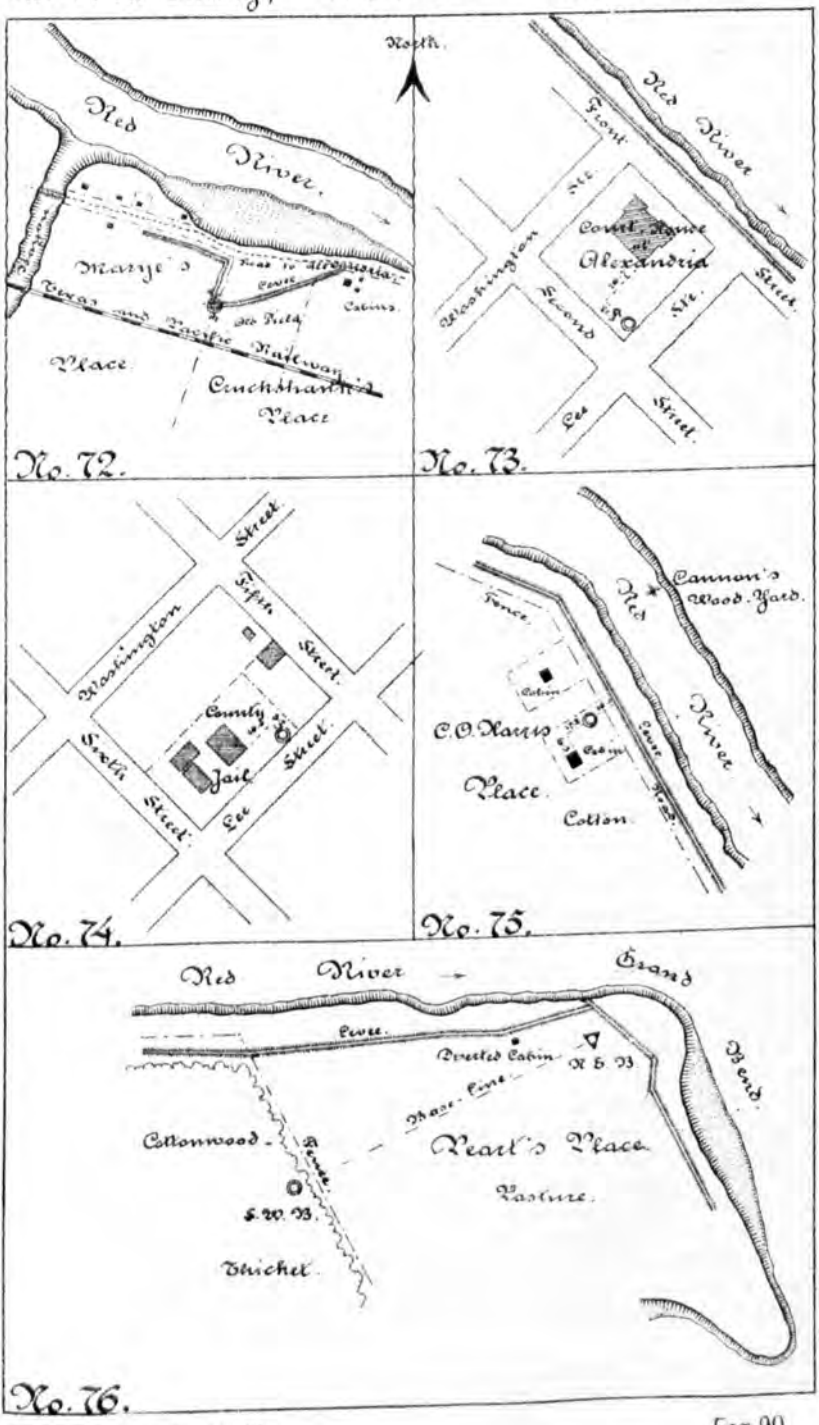


Photo-Lith. by A. HOEN & CO., Baltimore, Md.

Table 7.—Elevation of zeroes of gauges on Red River and its tributaries.

Locality.	Stream.	Established by—	Elevation of zero referred to Cairo datum.
			Meters.
Fulton, Ark	Red River	United States engineers.	Undetermined.
Garland City, Ark	do	do	Do.
Collin's Bluff	do	do	+64.94
Shreveport	do	do	+49.15
Coushatta	do	do	+35.33
Alexandria	do	do	+19.65
Monroe	Ouachita River	United States Steamship.	+15.71
Vicksburg, Shreveport, and Pacific Railroad Crossing.	Crew Lake	Vicksburg, Shreveport, and Pacific Railroad.	— 0.90
Do	Boeuf River	do	+ 0.18
Do	Bayou Macon	United States Steamship.	+21.60
Do	Censas River	Vicksburg, Shreveport, and Pacific Railroad.	+ 0.38
Do	Lake One	do	— 2.93
Do	Cypress Bayou	do	+ 0.26

W 2.

IMPROVEMENT OF OUACHITA AND BLACK RIVERS, ARKANSAS AND LOUISIANA.

Ouachita (the Indian name for black) River has its source in Polk County, Ark., in the Ouachita Mountains, and following an irregular course, flows in a general southeasterly direction through Arkansas and Louisiana, until joined by Tensas and Little rivers at Trinity, La. Below this junction it is known as Black River, and flows in a southerly direction, entering Red River about 40 miles above its mouth. The entire length of Ouachita River is about 500 miles, and Black River is 47 miles long.

Examinations were made by the United States in 1871, and a project submitted for temporary improvement from Arkadelphia to the mouth, by the removal of snags and by dredging at the worst bars, at an estimated cost of $98,300 (334–'46, Report Chief of Engineers, 1871). Work was commenced the same year. In 1871–'72 a survey from Camden, Ark., to Trinity, La., was made, the report on which recommended improvement by locks and dams (367–'74, Report Chief of Engineers, 1872), and a contract was made for timber for foundations of three locks. In February, 1873, the maps and notes of the survey were reviewed by Colonel Simpson's assistants, who condemned the survey and recommended that it be done over. This was ordered by the Department and completed by Major Benyaurd in 1874, who advised that the costly scheme be abandoned. This recommendation was approved, the contracts for timber annulled, and the material, which cost over $20,000, sold at auction and the net proceeds, somewhat less than $900, turned into the Treasury. The project under which operations are now conducted was then adopted. This contemplates the removal of wrecks, logs, snags, leaning timber, etc., and the improvement of shoal places between Camden, Ark., and the mouth of Black River, a distance of 341 miles.

No estimates of cost are given, as the nature of the work requires that it be continuous. (Reports Chief of Engineers, 1874, part 1, p. 352; 1884, p. 1386; 1887, p. 1487, and 1889, p. 1631.)

The appropriations have been as follows:

Act of—	
March 3, 1871	$51,000
June 10, 1872	100,000
March 3, 1873	60,000
August 14, 1876	12,000
June 18, 1878	10,000
March 3, 1879	10,000
June 14, 1880	8,000
March 3, 1881	12,000
August 2, 1882	12,000
July 5, 1884	15,000
August 5, 1886	17,500
August 11, 1888	20,000
Total amount appropriated to June 30, 1890	327,500

The amount expended on present project to June 30, 1889, was $198,077.16. The iron-hull snag-boat *O. G. Wagner* was completed in 1875, and has operated successfully in the river since. The small wooden steamer *Hooker* was purchased in 1888, and fitted up for light snagging in Ouachita River and tributaries. The work consisted principally of removing logs and snags from the channel and cutting leaning timber. Besides the removal of obstructions, an increased depth of from 1 to over 3 feet was gained at some of the shoals by constructing stone and brush wing-dams.

In the fiscal year ending June 30, 1890, operations were as follows:

The U. S. snag-boat *Meigs*, P. R. Starr, master, left Vicksburg, August 14, entered Black River the 17th, and proceeded up-stream to Taylor's Bar, 25 miles below Monroe. As there was but 18 inches of water on the bar, with the river falling, the boat turned back and worked between that point and the mouth of Black River until September 20, removing all snags, etc., obstructing the channel in this stretch of river. After reaching the mouth, the river still being too low to permit the boat to go above Taylor's Bar, it was returned to Vicksburg, arriving September 23. The remainder of September was spent in making minor repairs, necessary before resuming operations.

By reason of the extreme low water, this work was done thoroughly, and the master of the snag-boat reported that there were no obstructions left in the river below Taylor's Bar except sand-bars and shoals.

August and September, always the most unhealthy months in this climate, were unusually sickly on account of the low and almost stagnant water, and a severe type of malarial fever (hematuria) prevailed on the snag-boat, resulting in the death of three of the crew.

The following is a summary of the work of the *Meigs*:

Snags pulled	291
Stumps removed	739
Logs removed from channel	40
Shore snags cut	975
Leaning trees cut	976
Square yards willows and brush cut	40
Wrecks removed*	1

The chopping party which had been working above Camden, under the superintendence of Walter S. Davis, reached that place December 19, and the stage of water remaining favorable, continued down-stream. The gauge at Camden, December 20, read 7.1 feet and falling slowly, and there was 4 feet of water on the bar directly below the landing.

*Part of steamer *Dr. Beatlie* (sunk 1863) obstructing channel opposite Midway Landing.

Operations were carried down to Whitehall Landing, 12 miles below Camden, where work was stopped by a sudden rise January 6. Hodger's Shoal, a few miles below Camden, had but 2½ feet of water over it, and was obstructed by a number of logs. The logs were removed, and, as an experiment, a number of blasts with dynamite were made, breaking through the conglomerate bed of the shoal. Underlying this was a stratum of quicksand which scoured out quickly, and within a few days a wide channel 8 feet deep was obtained.

The following is a summary of the work of the chopping party:

Snags removed from channel	140
Stumps removed from channel	16
Shore snags and stumps removed	815
Leaning trees removed	5,309
Trees girdled	2,383

December 20, the steamer *H. Hanna Blanks* grounded on Romeo Shoals, 67 miles below Camden, and did not get off till near the end of the month, and it is stated that the boat sustained damages which were the cause of its sinking before it could reach Monroe.

Having ordered the snag-boat *Meigs* to resume work in Ouachita and Black Rivers early in January, I took advantage of the trip to make an inspection of those streams and Lower Red River. After completing the inspection of the latter, I continued up the Ouachita to the wreck of the steamer *Blanks*, about 10 miles above Monroe. The river, already high, was rising rapidly with no prospect of a favorable stage for operations for some time to come, and on January 22, I telegraphed Superintendent Davis to lay up the plant below Camden, and returned with the *Meigs* ot Vicksburg, arriving here January 28.

Continued high water has prevented operations since, but it is proposed to put a snag-boat and chopping party to work as soon as practicable.

In January Superintendent Davis made a reconnaissance of the river from Camden to Monroe, from the pilot-house of the steamer *John Howard*, for the purpose of noting the worst obstructions pointed out by the pilots. A copy of the notes is filed in this office for future use.

Since the abandonment of the project for improvement by locks and dams, three examinations have been ordered with a view to slackwater navigation. The first was made by Major Miller in 1883, and the others by me in 1887 and 1889, and all the reports agree that the work should be continued under the project recommended by Major Benyaurd and approved by the Department in 1874, and under which operations have been carried on ever since. I am still of the opinion that this plan should be continued until the country shall be more thickly settled, and increased business developed to warrant a large expenditure for permanent improvement. In the absence of an elaborate survey of the whole valley of the Ouachita, it would be mere guess-work to say what the ultimate cost of a slackwater system would be, and a survey of the character required would be an expensive undertaking, and could not be justified unless there was a strong probability that a plan involving an expenditure of not less than $3,000,000 would be authorized, with an annual charge for removing snags, etc., and for maintenance, at least equal to the appropriations granted heretofore. With reference to this subject attention is invited to the following report, submitted December 21, 1889:

In answer to your indorsement of December 9, on letter from Hon. Charles J. Boatner, to the Secretary of War, asking for estimate of cost of survey of Ouachita River

to Camden, Ark., with a view to securing permanent navigation by means of locks, I have the honor to submit the following:

A number of surveys, examinations, and reports have been made upon the subject of permanent improvement of Ouachita River, the last by me under date of February 12, 1889, giving a brief summary of plans, estimates, etc., which is published in Appendix W 22, Report of the Chief of Engineers, 1889.

The survey of 1871 upon which the first estimates were made, was condemned by a Board appointed by Colonel Simpson, and so many errors were found upon comparing the maps and notes with the survey of 1873 as to render it valueless even as a reconnaisance.

The report of the Board, with a review of the same, was forwarded to the Chief of Engineers by Colonel Simpson in his letter of March 11, 1873. The subject is discussed again by Major Benyaurd in his report on the resurvey of 1873 (Report of the Chief of Engineers, 1874, Part I, page 352.) The survey of 1873 is not discredited, and doubtless can be used to a certain extent, but how far I can not estimate, as it was made under conditions that do not now exist. I presume the original map and plans are on file in the Engineer Department, but the field-notes and copies of the maps, with a limited amount of topography, are at hand, and from such study as I have been able to give them, in the brief time that I could spare, I should say that as they will be over seventeen years old by the time field work could be resumed, should a new survey be ordered, their value for purposes of estimate must be limited.

The reasons for this opinion are based upon the facts that Ouachita River, being an alluvial stream, has undoubtedly undergone considerable change since 1873, and especially that all the eastern tributaries are now, or soon will be, deprived of a great part of their supply by the closing of the Arkansas and Louisiana lines of levees along Tensas Front, and will be limited hereafter to draining their own water-sheds.

The amount of money spent by the United States in combination with the States and parishes, corporations, and private parties in the construction of new levees, and repair of old is so great as to warrant the belief that no expense will be spared in the future to maintain the west line of levees.

Now since canalization is generally accepted as the only certain means of giving permanent navigation to a river like Ouachita, the minimum water-supply must be determined first of all, and to do this requires that the survey of Ouachita River should embrace the principal tributaries from Camden to Red River.

These are Little Missouri, Moro Bay, Saline River, Bayou D'Arbonne, Bayou Bartholomew, Bayou Bœuf (Bœuf River), and Tensas River and Bayou Macon. The map of the alluvial valley of the Mississippi River, issued by the Commission in 1887, shows most of the valley of Ouachita and tributaries formerly overflowed, and while much of this will be reclaimed by the closing of Tensas Front, it will be important to know the amount that might be flooded by backwater due to dams on Ouachita, to settle questions of land damages, etc., and this would necessitate frequent trans-valley lines.

The first thing in order should be precise leveling on Ouachita from Arkadelphia or Camden to Red River, and a few trial lines from the main river to the tributaries, to ascertain the probable lengths of the latter that would require the same or nearly equal grade of survey. I say the same or nearly equal grade, because if Ouachita is to be canalized it is hardly to be doubted that the dams could be so placed as to give no inconsiderable slackwater navigation to the tributaries at the same time; while on the other hand the tributaries must play an important role in limiting the heights of dams and lifts of locks, and hence in deciding upon the number and position of them in the main river.

Assuming for example that both banks of Ouachita are high enough to allow a lock of 8 to 12 feet lift below Bœuff River, a slackwater depth of about 4 feet might be obtained for a distance of 40 or 60 miles on Ouachita and Bœuff Rivers at the same time, but only, perhaps, by flooding a greater or less amount of land between the two streams. Now the only information I have in regard to the lands between Ouachita and Bayou Bœuff that I can offer as fact is that on the line of the Vicksburg, Shreveport, and Pacific Railway the land is about 20 feet lower at Bayou Lafourche, about midway between Monroe and Girard, than at the Ouachita or Bayou Bœuff, and the map indicates that in the neighborhood of Columbia the drainage is indifferent towards Ouachita or Bœuff, and may flow from one to the other according to variations in respective stages.

I think enough has been said to show the necessity of an exhaustive survey of the whole valley. The information should be so complete as to leave nothing to chance, and, therefore, the survey should cover precise levels along both banks, and frequent trans-valley sections; high and low-water slopes, discharge and sediment observations; topography, taking in the valley for a mile on each side, or more if necessary, and connecting with the principal tributaries at intervals; hydrography; sections and longitudinal soundings; secondary triangulation; special examinations and borings at probable sites for locks; permanent bench-marks and monuments; projection of maps; computation, office work, etc.

The estimates for locks and dams heretofore submitted vary from, say, two to six millions of dollars, and in my opinion the latter is none too small for a system of locks and dams between Camden and Black River, considering the nature of the foundations probably to be encountered.

The rise and fall at Camden is 39.25 feet, at Monroe 46 feet, at Boeuf River over 52 feet, and at Trinity 53.4 feet, so that it is clear that whatever system were chosen, whether fixed or movable dams, locks of high or low lift, none but the most substantial work would be admissible, as complete submergence of the locks and maneuvering engines, boilers, etc., would have to be provided for at any stage over, say, 20 feet above low water. The great variations in rise and fall as stated, though under the changed conditions it may be much less in the future, warrants the belief that both revetments and levees may be required to prevent flanking the dams and locks, a disaster that would not be local and to be remedied by the expenditure of a hundred thousand dollars or so, but one that would mean the destruction of the system or the interruption of navigation for years and the expenditure of an immense sum for its restoration. Six millions of dollars would not be an extravagant sum to pay for a permanent navigation of Ouachita River that would also give from 40 to 100 miles on each of its large tributaries, say about 1,000 miles in all, giving an average of $6,000 the mile. But whether the ultimate cost should be found to be greater or less than the estimates heretofore submitted, true economy demands a most thorough and exhaustive survey, always a very expensive undertaking.

As much of the country to be gone over is unsettled it would require that the parties should be maintained in the field, in camp, or on quarter-boats, for two seasons, or longer, if operations should be interrupted by high water or sickness; high pay in the field and office, as only the best men should be employed, and expensive instruments suited to the grade of work demanded.

It is very difficult to make an estimate, because it can not be determined how much work will be needed on the tributaries until they have been examined, nor how much of the survey of 1873 can be used until it has been reviewed both in the office and in the field.

First class work can be done for about the following rates per mile: Secondary triangulation, $125, if the country is reasonably open, so that high stations or much cutting will not be required; topography, hydrography, and precise levels along the river, $150; precise levels and transit lines across country, $50; discharge and sediment observations, according to the number of stations and time allotted. The last is very uncertain, on account of interruptions and delays by floods and unfavorable conditions.

Ouachita and the tributaries are subject to sudden and considerable floods, though the highest water occurs generally in March and November, so that it is probable that field work of the survey could be carried on for about nine months in the year.

On this basis, and making allowances for interruption from sickness and bad weather, I estimate that the survey could be completed and the notes and estimates prepared in about two years and a half, and at a cost of $150,000, or about two and a half per cent. of the estimated cost of the improvement.

The amount estimated for the fiscal year 1892 can be expended to advantage of commerce and navigation in continuing operations under the present project. In addition to the work of snag-boats I recommend the systematic clearing of the banks for some distance back. This is especially necessary in the bends and narrower portions of the river for the immediate benefit of navigation, but should be continued throughout the whole stream to prevent the formation of obstructions. Dredging should be tried also at the most obstinate shoals, and the construction of inexpensive wing-dams, built chiefly with the material cut from the banks.

A great deal of complaint has been made about the location of the low dams at Catahoula Shoals, and steam-boat men insist that navigation would be better and safer if the channel were cut through the old dam and the present opening closed. The crossing is certainly in a very bad condition now and unsafe at certain stages, but a change should not be made until a survey has been made for a distance of a mile or so above and below the shoals, to determine the best line for the dams. The dams were planned so as to utilize as much of the old State dams as possible, and so accomplish the desired result at the least cost, the appropriation being limited.

I made a personal examination of the river at the shoals in January

and was satisfied that the desired relief ought to be given, but the water has remained too high to make a survey since that time. From an examination of the old maps, however, I think that a new channel could be dredged, and the opening now used closed with stone for about $5,000, to which would have to be added $1,200 for two dump-scows and $800 for bringing the dredge from Upper Red River to the work and return, or in all $7,000.

While in the river, and before or after this work is done, according to the stage of water, the dredge could be used to great advantage in cutting through the shoals in Black River, some of which have as little depth as 16 inches at low water. Where the material is hard, or heavy gravel, it could be deposited on such lines as to form wing-dams, and so confine the low-water channel to the desired line and still maintain the pool above to some extent. The dredging should not be carried to a depth of more than, say, 3 feet, because the reduction of the low-water line would only transfer the shoal-water to some gravel bed farther up stream. For this experimental work the estimate is $6,000.

In connection with the general improvement of the stream an examination of the old State levees on both sides of the river should be made, in order to furnish a basis for estimates for their restoration and for strengthening their profile. The estimate for this work is $3,200.

The estimates for flat-boats, skiffs, and outfit for the chopping parties is $2,000; and for wages, subsistence, and material, $12,000.

For the snag-boat service:	
The *Wagner*, eight months' active work and four months in ordinary	$16,000
The *Hooker*, eight months' active work and four months in ordinary	6,800
For services of other boats from time to time, repairs, outfit, explosives, contingencies, and office expenses	7,000
The estimates for general improvement are	60,000
And for the general survey	150,000
Total	210,000

Money statement.

July 1, 1889, amount available		$15,384.97
July 1, 1890, amount expended during fiscal year, exclusive of liabilities outstanding July 1, 1889	$8,660.08	
July 1, 1890, outstanding liabilities	2.89	
July 1, 1890, amount covered by uncompleted contracts made during fiscal year ending June 30, 1890		8,662.97
July 1, 1890, balance available		7,172.00
Amount appropriated by act of September 19, 1890		15,000.00
Amount available for fiscal year ending June 30, 1891		22,172.00
Amount that can be profitably expended in fiscal year ending June 30, 1892		60,000.00
And, in addition, for survey of Ouachita River and tributaries		150,000.00

Submitted in compliance with requirements of sections 2 of river and harbor acts of 1866 and 1867.

COMMERCIAL STATISTICS.

During the past fiscal year there was good navigation in Ouachita and Black rivers for the larger steam-boats as follows: For six months to Camden, 341 miles from the mouth of Black River; for nine months to Monroe, 174 miles; and for ten and a half months to Harrisonburgh, 67 miles. During the periods of freshets from the Ozark Mountains, and contiguous water-sheds, boats could go up to Arkadelphia, 417 miles above the mouth, but Camden was considered the head of navigation last

season. Ten steamers plying between the headwaters of the river and New Orleans attended to the trade proper of the Ouachita. In addition to these boats, three steamers were sent out from St. Louis, making a total of 5 trips from that port. Thirteen smaller steamers were engaged in the tributary trade. There are 333 regular freight landings on Ouachita and Black rivers.

The following steamers were engaged in the Ouachita River trade during the past fiscal year:

Name.	Registered tonnage.	Draught.		Round trips.
		Light.	Loaded.	
		Ft. In.	*Ft. In.*	
St. John	382.33	3 0	9 0	27
John Howard	329.69	2 2	8 0	12
Assumption	238.41	3 0	8 0	4
H. Hanna Blanks	352.75	2 2	7 0	11
Josie W	156.40	2 2	6 0	10
G. W. Sentell	306.76	2 2	6 0	5
Alto	363.16	3 0	6 0	5
Era No. 10	176.89	2 0	5 0	1
Prince	107.88	2 2	3 0	2
Ida B. Cothell	57.05	2 2	2 2	1
Savannah	.....	.....	.....	3
Bald Eagle	454.71	.....	.....	1
Pike	.....	.....	.....	1

The *Savannah*, *Bald Eagle*, and *Pike* were sent out from St. Louis, and with the exception of two trips of the *Savannah*, each had a loaded barge in tow. The other boats ran to New Orleans.

	1888-'89.	1889-'90.
Freights:	*Tons.*	*Tons.*
Cotton	17,788	16,652
Cotton seed	2,660	5,058
Hides and skins	23	36
Live stock	213	62
Lumber	5,963	7,951
Staves	8,599	21,159
Sundries	1,096	783
Total down freight	36,342	51,701
Return freight, merchandise	24,228	40,766
Total freights	60,570	92,467
Total value	$3,798,000	$10,109,250

In addition to the above the log output for the past season for Ouachita and tributaries, it is estimated, aggregated 10,000,000 feet (board measure) sawed lumber, in value equal to $125,000.

The advent of two new railroads has affected the commerce of the Ouachita and tributaries; the New Orleans and North Western that crosses the Lower Tensas River, and the Houston, Central Arkansas, and Northern Railroad at Monroe, La. The latter runs northwest 25 miles and in a southerly direction about the same distance, and during past season it transported 7,785 bales of cotton that otherwise would have been carried by the boats. This road recently has been added to the Missouri Pacific system, and is extending in a northerly direction to Dermott, Ark., and to Alexandria on the south. The New Orleans and North Western, now under construction, crosses the Vicksburg, Shreveport and Pacific at Rayville, La., the St. Louis, Iron Mountain, and Southern Railway crosses the Ouachita at Arkadelphia, the Vicksburg, Shreveport and Pacific crosses at Monroe, and a bridge of the Houston, Central Arkansas and Northern Railroad is contemplated near Columbia. A narrow-gauge road connects the Ouachita, at its confluence with Black, Tensas, and Little rivers, with the Mississippi River at Vidalia, La., directly opposite Natchez. This road has a small steam-boat that carries the mail and supplies on Black River from its mouth down.

W 3.

IMPROVEMENT OF OUACHITA RIVER, ARKANSAS, ABOVE CAMDEN.

An examination of this part of the Ouachita River was made in 1887 (1495–1497, Report Chief of Engineers, 1887), and the plan recommended for its improvement contemplated cutting the leaning timber, girdling trees, removing snags and logs, and building brush dams at the shoals, between Camden and Arkadelphia, Ark. (76 miles), to render that portion of the river navigable at a stage that affords navigation to the former place, at an estimated cost of $9,000.

The river and harbor act of August 11, 1888, appropriated $9,000 for this purpose.

A light-draught flat-boat (60 by 16 feet), for quarters of employés and storing tools and supplies, and a smaller boat (25 by 12 feet) for use with hand capstan, were built at Arkadelphia, a chopping party of thirty men organized, and work was commenced at that place September 25, 1889, and continued down-stream to Camden, which was reached December 19. Favorable conditions for work prevailed until November 9, when unusual rains set in and continued at intervals until November 27. After the latter date rapid progress was made, and upon arrival at Camden the party was transferred to the work of improving the river below.

The following is a summary of the work done:

Snags and logs removed from channel	3,117
Stumps removed from channel	12
Cubic yards of rock-reef excavated	11
Cubic yards of stone wing-dams built	66
Lineal feet of brush wing-dams built	100
Shore snags and stumps removed	1,924
Leaning trees removed	25,885
Trees girdled	13,484
Square yards of brush and willows cut	138,563

Mr. Walter L. Davis, under whose supervision the work was carried on, reported in December that the river was in fair condition for navigation above Camden to Arkadelphia at stages that would permit steamers to run to the former place, all work having been done at low water, except a short stretch of about 8 miles between Bear Head Island and the mouth of Little Missouri River.

I am informed that this work has enhanced the value of timber lands bordering the stream very considerably, and that the merchants of Arkadelphia are building a light-draught steamer to ply between that place and Camden, and Monroe, La., both to gain the advantge of river competition and to build up a trade at the landings between Arkadelphia and Camden for the people who now have to haul long distances to railroads. The railroad rate on cotton from Arkadelphia to St. Louis is $3.50 per bale, and to New Orleans it is $3.85 per bale. The river rate from Camden to New Orleans is only $1.50 per bale, and steam-boats propose to transport it from Arkadelphia at $2 per bale. So far, however, none of the business has been diverted to the river, and none of the regular Ouachita boats go higher than Camden, giving the reason that as the merchants of Arkadelphia have taken no steps to ship by river they still regard Camden as the head of their trade.

It is proposed to expend the available balance in going over the work during the next low-water season, and completing it in accordance with the project.

Money statement.

July 1, 1889, amount available	$9,000.00
July 1, 1890, amount expended during fiscal year	6,559.26
July 1, 1890, balance available	2,400.74

W 4.

IMPROVEMENT OF BAYOU D'ARBONNE, LOUISIANA.

Bayou d'Arbonne is formed by the junction of the South, Middle, and North, or Corney Branches, near Farmerville, in northern Louisiana; flows in a southeasterly direction, and enters Ouachita River 6 miles above Monroe, La.

An examination and a survey were made in 1883 (pages 1372–1381, Report of Chief of Engineers, 1884), and the plan of improvement is based upon the latter. The bayou is navigable during high stages only, and the project contemplated the removal of snags, logs, wrecks, leaning trees, etc., obstructing navigation from Stein's Bluff, on Bayou Corney, to the mouth, 42½ miles, at a cost estimated at $5,000. This, it was thought, would lengthen the season of navigation about two months, besides rendering it less hazardous at all times.

The following appropriations have been made for this work:

By act of—	
July 5, 1884	$5,000
August 5, 1886	2,000
August 11, 1888	2,000
Total appropriated and expended to June 30, 1890	9,000

Operations were begun in 1884 and continued in 1886 and 1887 under the first two appropriations, resulting in the removal of a large number of obstructions from the lower part of the stream, for 29 miles above its mouth, putting that stretch in fairly good navigable condition, and effecting a reduction of about 20 per cent. in freight rates. Work under the act of 1888 was not commenced until June 18, 1889, giving but thirteen days operations in that fiscal year. Before this improvement was undertaken by the United States considerable work had been done by the steam-boat men, in the way of clearing the leaning timber and removing the worst snags, and at the time the survey was made the bayou was navigable six to seven months in the year; during the fiscal year 1888–'89 it was navigable for eight months, November to June, inclusive, boats running to Stein's Bluff during that period.

During the past fiscal year operations have been as follows: The water reached a stage so low that the snag boat *Hooker* had to be withdrawn July 4. The chopping party continued operations between Stein's Bluff and Rugg's Bluff until August 2, 1889, when the available funds were exhausted and the party and outfit were transferred to the improvement of Bayou Bartholomew. Owing to unusual rains, the bayou frequently was at a stage unfavorable to the removal of channel obstructions, and a sudden rise July 10, followed by heavy rains, rendered a temporary suspension of all work necessary for a period of nine days. During this interval all employés except the overseer, watchman, and cook were laid off.

The following is a summary of the work performed:

	Number.
Logs and snags removed from channel	461
Stumps removed from channel	134
Shore snags removed	988
Leaning trees removed	2,299
Leaning trees topped	2
Leaning trees girdled	9,196
Square yards willows and brush cut from banks	425
Logs on banks cut up, to prevent their becoming obstructions	931

The work was conducted under the superintendence of Walter S. Davis, who reports that the country benefited by the improvement is well settled and improving rapidly, and that the people have no other means of reaching market, except by hauling in wagons over rough roads.

The estimates given in the report of the survey were for $15,000, to be spent in two consecutive seasons' work; only three-fifths of this amount has been appropriated in a period of six years, but it has been expended to such advantage that the stream is in fairly good navigable condition to Stein's Bluff during high stages, and the season of navigation has been prolonged slightly. The work is not permanent, as new obstructions are added from time to time, but it can be performed with such thoroughness as not to require attention for some years to come if the balance of the original estimate is made available in the next appropriation.

Capt. E. B. Cryer, of Monroe, La., who has been engaged in navigation of Ouachita River and tributaries for twenty-seven years, reported under date of April 23, 1890, regarding the D'Arbonne, as follows:

The benefits have been general so far as the work has been done. High-water navigation has been benefited most. Before the chopping out was done, boats of 500 bales of cotton capacity were as large as could be operated to any advantage. Now boats of 1,000 bales capacity can be navigated with less difficulty. Freight rates on cotton and merchandise have been reduced fully 50 per cent. Insurance is the only thing that has not been reduced, but that, I think, is on account of this territory being left subject to the dictates of the New Orleans board of underwriters. In many cases the rate of insurance equals the freight rate charged by the steam-boats.

What the bayou needs most at present is a snagging outfit, with a small, strong flat-boat fitted with shears and a steam capstan, or other pulling power, to remove stumps and logs from the channel. If this were done, it would give navigation thirty days earlier in the fall and thirty days later in the summer, which would be as great a benefit as can be given to the merchants and planters on the bayou, as the thirty days early navigation come when all available force are engaged in saving the crop, and the thirty days of late navigation in the spring come when every available hand and horse or mule are plowing.

Money statement.

July 1, 1889, amount available	$1,000.00
July 1, 1890, amount expended during fiscal year, exclusive of liabilities outstanding July 1, 1889	1,000.00
Amount appropriated by act of September 19, 1890	2,000.00
Amount (estimated) required for completion of existing project	4,000.00
Amount that can be profitably expended in fiscal year ending June 30, 1892	4,000.00

Submitted in compliance with requirements of sections 2 of river and harbor acts of 1866 and 1867.

COMMERCIAL STATISTICS.

During the fiscal year this stream was navigable for regular packets for a period of seven months, as far up as Stein's Bluff. This point is considered the head of navigation at present, although for a period of six months boats went as far as Shiloh

Landing, 56 miles. Private parties cleared the obstructions that made this impossible before. Whenever navigation suspends on this or other tributaries of the Ouachita, rates on cotton advance at once. It costs $1.25 per bale to haul to Delhi, and $2.25 per bale by rail from that point to New Orleans. The rate by river to New Orleans is $1.50 per bale.

Steam-boats navigating Bayou D'Arbonne.

Names.	Registered tonnage.	Draft.		Round trips.
		Light.	Loaded	
		Ft. In.	*Ft. In.*	
Lake Washington	96.39	2 0	4 0	20
Rowena	8.88	1 0	2 2	20
Tributary	93.78	1 2	3 2	20

Freights.

	1888-'89.	1989-'90.
	Tons.	*Tons.*
Cotton	2,500	1,500
Cotton seed	.....	1,000
Hides	5	.....
Total down freights	2,505	2,500
Return freights	1,670	1,666
Total freights	4,175	4,166
Total value	$500,600	$626,000

Ten thousand two hundred and fifty logs valued at $20,000 were reported rafted out during past fiscal year.

W 5.

IMPROVEMENT OF LITTLE RIVER, LOUISIANA.

This stream is formed by Dugdemona River and Bayou Castor at the junction of Winn, Grant, and Catahoula parishes, Louisiana, flows in a southeasterly direction, and enters Catahoula Lake. The outlet from Catahoula Lake on the northeast is called Little River also, and flows in a northeasterly direction, uniting with Ouachita and Tensas at Trinity, La., in forming Black River.

An examination was made by the United States in 1887 (pages 1498–1499, Report Chief of Engineers, 1887), and the project based thereon contemplated removing sunken logs and cutting the most obstructive leaning timber in the outlet from the lake to Trinity, about 25 miles, at until June a cost of $2,500.

The river and harbor act of Augnst 11, 1888, appropriated $2,500 for this purpose, and operations were begun May 23, 1889, and continued 13, 1889, when high water stopped the work.

On the 1st of January, 1890, work was resumed by the United States snag-boat *Hooker*, Watkins Decker, master, and completed January 18. Operations extended over the entire portion of the river included in the project, and the following is a summary of the work performed:

	Number.
Snags removed from channel	104
Stumps removed from channel	13
Shore snags removed	34
Side jams removed	6
Leaning trees removed	156
Trees girdled	362

The work contemplated by the project having been completed, no further estimate is made for this stream.

Money statement.

July 1, 1889, amount available	$791.73
July 1, 1890, amount expended during fiscal year, exclusive of liabilities outstanding July 1, 1889	791.73

COMMERCIAL STATISTICS.

Data for obtaining the amount of commerce of Little River could not be obtained. It was said by those who are directly interested in the trade to have been at least 10 per cent. better than the previous year, on account of high stages of the water for an unusually long period.

W 6.

IMPROVEMENT OF BAYOU BARTHOLOMEW, LOUISIANA AND ARKANSAS.

This stream rises in southeastern Arkansas within a few miles of Pine Bluff, and, following a tortuous course, flows at first nearly parallel to Arkansas River, at a distance varying from 15 to 30 miles; then parallel to the Mississippi, at about the same average distance, but after entering Louisiana turns to the southwest and enters Ouachita River opposite Ouachita City. The total drainage area of the bayou and its tributaries is about 1,800 square miles. The States of Louisiana and Arkansas have made expenditures at various times for the survey and improvement of this stream, navigation in it having been carried on to a considerable extent as early as 1843.

Examinations were made by the United States in 1872, 1879, 1880, and 1884. (Reports Chief of Engineers, 1872, pages 383–386; 1879, pages 997–1003; 1881, pages 1453–1457; and 1885, pages 1548–1552.) The project contemplates the removal of snags, logs, wrecks, leaning timber, etc., obstructing navigation from Baxter, Ark., to the mouth, a distance of about 213 miles. New obstructions are forming continually, hence no estimate for permanent improvement is given.

The following appropriations have been made for this work:

March 3, 1881	$8,000
August 2, 1882	5,000
July 5, 1884	5,000
August 5, 1886	5,000
August 11, 1889	5,000
Total appropriated to June 30, 1890	28,000

Operations were begun in 1881, and continued in 1882, 1884, and 1886–'87. This work extended over nearly the entire portion of the bayou included in the project, and lessened the dangers of navigation greatly. Before the improvement was commenced three months was the average duration of the navigable season; in 1888 it was reported that the period had been increased to six months by the removal of obstructions, and that boats made trips in about one-third less time, reducing freight rates about 33⅓ per cent.

During the fiscal year 1889–'90 operations were as follows: After suspending operations in Bayou D'Arbonne, August 2, the chopping

party and outfit were transferred to this stream. The snag-boat *Hooker* was used for this purpose, and four days were spent in making preparations and in towing the flat-boat from D'Arbonne into Bartholomew. On account of the low stage of water, the snag-boat could not go higher than Farmer's Landing, 9 miles above the mouth, and after working from this point back to the mouth, was returned to Monroe, La., and laid up. The chopping party continued operations up-stream to Oak Landing, about 90 miles above the mouth. This point was reached November 21, and the available funds being nearly exhausted, the flat-boat worked down-stream to Monroe, arriving there November 29, when the party was disbanded. This work was commenced under the superintendence of Walter S. Davis, but his services being required on the Ouachita above Camden, he was relieved August 16 by Overseer Watkins Decker, under whose efficient management it was continued to the end of the season. The party was divided into two squads, one being employed in clearing the banks and the other in removing obstructions from the channel, the latter work being accomplished by means of high explosives and the use of blocks and tackle. The water was at a stage favorable to successful operations, as is shown by the following summary of the work performed:

	Number.
Leaning trees removed	26,371
Trees girdled	23,252
Shore snags removed	6,501
Square yards willows and brush cut	9,325
Logs and snags removed from channel	2,466
Stumps removed from channel	8,049
Side jam removed	1
Wrecks removed (steamers *Big Horn*, *Bastrop*, and one name unknown)	3

The following extract from Overseer Decker's report will give a good idea of the benefits derived from the work of the past year:

A great many trees had caved into the bayou, catching sediment and forming bars, and in some places the accumulations were such that small islands had formed, on which small willows were growing, notably one-half mile below Townsend's Ferry, Spyker Place, and between Lum Ward's Ferry and Hope's Warehouse. The benefit to navigation derived from the removal of these obstructions was perceptible immediately, as the sand would wash away and leave a clear channel as soon as the trees were removed.

The destruction of stumps in the channel has lessened the danger of navigation greatly, and the removal of the three steam-boat wrecks was a signal service to low-water navigation. The cutting of leaning timber will enable steam-boats to make quicker time, and the girdling of the trees along the banks will decrease the cause of future obstructions. The benefit derived from the latter is not seen directly, but in a short time the limbs will decay and drop off, and should the trunks be carried into the stream at any time there is little likelihood of their becoming obstructions.

Everything taken from the bottom of the river tends to deepen the channel, and I can safely say that there is an average of at least 2 feet more steam-boat water from the mouth up to Point Pleasant (the present head of low-water navigation) than ever before.

Having received information that the bayou was much obstructed by drift, the United States snag-boat *Hooker*, Watkins Decker, master, left Monroe February 7 and made a patrol as high as Ohio Landing, Ark., about 118 miles above the mouth, returning February 19, after removing 2 jams, 13 side-jams, and 65 snags. The snags were chiefly large, floating butts, much dreaded by pilots on account of their uncertain location. The jams were caused by the large quantities of timber and brush cut last fall by the chopping party. This work exhausted the small balance of the appropriation, but cleared the bayou of jams and drift, and the steam-boat men have expressed themselves as well pleased with its performance.

The following letter was received from Capt. E. B. Cryer, of Monroe, La., April 28, 1890:

It gives me great pleasure to be able to enumerate to you a few of the great benefits derived from the work done under your direction on Bayou Bartholomew the last few years. Having been engaged in running steam-boats in the above bayou for the last twenty years, no one is better prepared to review the past and present condition of the stream.

When I first commenced to run steam-boats on Bartholomew, a boat carrying 500 bales of cotton could be navigated only with the greatest difficulty, I being compelled to spend large sums of money, individually, employing chopping parties to cut out leaning trees and remove drift and jams. It then required fourteen days for a 500-bale boat to make a trip to the head of navigation. The rate on cotton then was $5 per bale. Now the same trip can be made by a steam-boat carrying 1,000 bales in seven days, at a freight-rate of $2.50 per bale. Then the bayou could only be navigated about three months; now we have better navigation during six months.

What now is most needed is a good, strong flat-boat, with shears and steam capstan, to operate in the stream during low water, to lift out the logs and stumps that have slipped in off the banks or that have fallen into the bayou when they were cut to clear them out of the way of high-water navigation.

The commerce of this bayou is immense. This season about 3,000 bales of cotton, 100,000 sacks of cotton-seed, 300,000 staves, 2,000,000 feet of square oak timber for export, 3,000,000 feet of cypress timber in the logs, besides large quantities of hides and sundries, were brought out. This is an inside estimate of output and product of the bayou. The inward-bound freight will amount to about 3,000 tons or more. This bayou has never received the consideration to which it is entitled, from a commercial point of view, and I hope you will take my suggestion in reference to a flat-boat for snagging purposes under consideration and adopt it, as it will prolong navigation at least two months and benefit the people and commerce to that extent.

Money statement.

July 1, 1889, amount available		$5,000.00
July 1, 1890, amount expended during fiscal year, exclusive of liabilities outstanding July 1, 1889	$4,995.10	
July 1, 1890, outstanding liabilities	.34	
		4,995.44
July 1, 1890 balance available		4.56
Amount appropriated by act of September 19, 1890		5,000.00
Amount available for fiscal year ending June 30, 1891		5,004.56
Amount that can be profitably expended in fiscal year ending June 30, 1892 Submitted in compliance with requirements of sections 2 of river and harbor acts of 1866 and 1867.		10,100.00

COMMERCIAL STATISTICS.

Navigation in this stream began January 1 and remained good to the end of the fiscal year. Three steamers made a total of 42 round trips, connecting with larger boats at Monroe.

Name.	Registered tonnage.	Draught.		Round trips.
		Light.	Loaded.	
		Ft. In.	*Ft. In.*	
Josie W	156.40	2 0	6 0	20
Sterling White	117.09	2 0	4 0	12
Sallie	68.25	1 2	4 0	10

Commerce.

	1888–'89.	1889–'90.
	Tons.	*Tons.*
Cotton	530	2,000
Cotton seed	431	4,000
Total down freight		6,000
Return freight		4,000
Total freights		10,000
Total value		$452,000

Logs reported floated out 11,839, valued at $40,629. The commerce reported for 1888–'89 is only partial, so that a comparison is not possible. The statistics for this season are reliable.

W 7.

IMPROVEMENT OF BAYOU BŒUF, LOUISIANA.

Bayou Bœuf, usually called Bœuf River, rises in southeastern Arkansas, flows in a southerly direction, and enters Ouachita River at Stafford's Point, 8 miles above Harrisonburgh, La. Some work for the improvement of this stream was done by the State of Louisiana previous to the war, the report of the board of public works for the year 1840 showing that it was open to Point Jefferson.

An examination of the bayou was made by the United States in 1880, (pages 1424–1428 Report Chief of Engineers, 1881), and an examination of three outlets near Point Jefferson, La., was made in 1884, and their closure recommended (pages 1545–1548 Report Chief of Engineers, 1885). The project contemplates the removal of snags, logs, leaning timber, etc., obstructing navigation between Wallace's Landing and the mouth, about 280 miles. New obstructions are forming continually, and require removal from time to time, hence no estimate for permanent improvement is given.

The following appropriations have been made for this work:

By act of—	
March 3, 1881	$5,000
August 2, 1882	5,000
July 5, 1884	5,000
August 5, 1886	5,000
August 11, 1888	6,000
Total appropriated to June 30, 1890	26,000

Operations were commenced in 1881, and continued in 1882, 1884, 1887, and 1888–'89. The three outlets near Point Jefferson were closed in 1887 and 1888, at a cost to the United States of $5,441.78, and by confining the stream to its natural direction the season of navigation has been prolonged. All other work comprised the removal of snags, leaning timber, etc., and has lessened the danger of navigation and enabled boats to run to Point Jefferson, 19 miles below Wallace's, during high stages.

Owing to the small balance available for this improvement but three weeks' work could be performed in the past fiscal year, as follows: The United States snag-boat *Hooker*, Watkins Decker, master, left Monroe, La., December 11, and was employed the remainder of the month in

working over the 60 miles above the mouth. The principal work performed was the removal of large leaning trees in the bends, 2 to 3 feet in diameter, 50 to 75 feet high, and projecting 10 to 20 feet from the banks. By the use of high explosives these were blown out by the roots and then cut into short lengths so as not to become obstructions in the future. This part of the bayou was cleared thoroughly, and the master of the snag-boat reports that the work done will enable steamboats to make from six to eight hours better time.

The following obstructions were removed.

	Number.
Snags and logs from channel	98
Stumps from channel	32
Side-jams	1
Shore snags	89
Leaning trees	200
Leaning trees topped	24

With the appropriation asked for the fiscal year 1892, it is proposed to continue work by clearing the banks systematically, building brush wing-dams to scour the bars, and removing shore-slides and logs and snags from the channel. The snag-boat *Hooker* and a chopping party of fifteen to twenty men can be employed to advantage for at least six months at a cost approximating $1,650 per month.

The willful cutting of Opossum Fork levee, and the crevasses that occurred in the levees on the right bank of the Mississippi below, admitted an immense volume of water into the secondary valleys drained by Bayou Bœuf and Tensas and Macon.

When the outlets at Point Jefferson were closed it was threatened that they would be cut and the water allowed to escape into Ouachita River through Lake La Fourche, not with the view of relieving the intervening lands from flood, but to furnish a navigable route into the lake as far as the ferry on the road from Girard to Oak Ridge. It is said that the original levees had been cut by the same parties, or the same family, reported to have made these threats, and whether or not the levee was cut for the same purpose, or was washed away, they complained to me that the navigation of La Fourche which "they had made" was destroyed by "my dams."

The closing of these outlets was estimated for in 1884 (page 1,545, Report Chief of Engineers, 1885), and a small portion of the estimate was allowed to close one outlet by act of August 5, 1886. The outlet at Point Jefferson was closed substantially, the second was closed by a heavy dam at a lower elevation, and the third by a low dam, being all the work that could be done with insufficient appropriations assisted by contributions from the planters whose lands would be protected from overflow by continuing the dams to join the old parish levees.

I had warned the people interested in the preservation of the dams to keep a guard during high water, and this seems to have been done for several weeks. Mr. Hefner, of Oak Ridge, reported June 13:

> The dam at Point Jefferson is entirely gone. A guard was kept until interested parties were worn out, and, owing to the very isolated situation during high water the great difficulty was to get new men to relieve them. The dam stood all the water, and only after the water rose over the old north part and washed over the old part, and made a large washout across the end of the dam, it gradually washed away. After the water was high no dirt could be obtained, as it was all a mire. No. 2 is all there as I built it, but a new channel cut around the west end, owing to a want of height on the *old part* (*i. e.* the levee on the main line). No. 3 is nigh all gone, as you remember it was only built against rain-water (*i. e.* natural drainage). I feel positive there was no cutting of levees. If I had been able to build the works complete according to your plans, they would be all there yet.

The closing of these outlets is absolutely essential to maintaining Bayou Bœuf as a navigable river, and if they are left open no more money should be expended for its improvement. Incidentally a very fertile region would be protected against floods, and so property holders would be benefited without expending a penny directly for the work. Had the original estimates been filled, so that all three outlets could have been closed in the same manner as was No. 1, and the private subscriptions and parish funds applied to the connecting levees, it is not probable that even this year's high flood would have been broken through.

A new estimate is submitted of 50,000 cubic yards at 25 cents the yard, to include all expenses of inspection, clearing, and grubbing, and making a secure bond with the foundations and joining with the main line of levees some distance beyond the outlets on either side.

It will be useless to close only one outlet, and it should be stipulated that the parish levee board should join in and raise and strengthen the main line of levee above and below the outlets before work on the outlets themselves is begun, or that the State, parish, and subscribed funds should first be placed to the credit of some responsible person to be paid out for such work, so that all may be carried on continuously and on the same plan.

The estimates for the year 1892 are therefore:

For levees and dams, closing outlets	$12,500
For general improvement	10,000
For office expenses and contingencies	500
Total	23,000

Money statement.

July 1, 1889, amount available		$977.52
July 1, 1890, amount expended during fiscal year, exclusive of liabilities outstanding July 1, 1889	$955.43	
July 1, 1890, outstanding liabilities	22.00	
		977.43
July 1, 1890, balance available		.09
Amount appropriated by act of September 19, 1890		5,000.00
Amount available for fiscal year ending June 30, 1891		5,000.09
Amount that can be profitably expended in fiscal year ending July 30, 1892 Submitted in compliance with requirements of sections 2 of river and harbor acts of 1866 and 1867.		23,000.00

COMMERCIAL STATISTICS.

Navigation in this river began about December 15, and remained good until the end of the fiscal year. One steamer made a total of nine round trips during the season, viz:

Name.	Registered tonnage.	Draught.		Round trips.
		Light.	Loaded.	
		Ft. In.	Ft. In.	
Era No. 10	176.89	2 0	5 0	9

Commerce.

	1888-'89.	1889-'90.
	Tons.	*Tons.*
Cotton	1,084	1,397
Cotton seed	834	731
Staves	54	263
Sundries	91	.....
Total down freights	2,063	2,391
Return freights	1,376	1,594
Total freights	3,439	3,985
Total value	$457,094	$580,856

Bœuf River is crossed by the Vicksburg, Shreveport and Pacific Railroad near Girard, La., and another bridge is contemplated by the New Orleans and Northwestern Railway, to cross a few miles north of Girard.

W 8.

IMPROVEMENT OF TENSAS RIVER AND BAYOU MAÇON, LOUISIANA.

Tensas River has its source in Lake Providence, in northeastern Louisiana, flows in a southerly direction, and joins Ouachita and Little rivers at Trinity, La., in forming Black River. By the act of 1884 Bayou Maçon was united under the same head of appropriation with Tensas River. This stream rises in Desha County, southeastern Arkansas, flows in a southerly direction, and enters Tensas River about 40 miles above its mouth.

Examinations were made in 1880, upon which the plan of improvement is based. The project contemplates removing snags, logs, and leaning timber obstructing navigation; in Tensas from Dallas, La., to its mouth (about 180 miles) at an estimated cost of $23,000; and in Bayou Maçon from Floyd, La., to its mouth (about 130 miles) at an estimated cost of $17,000.

The following appropriations have been made:

Act of—	
March 3, 1881	$3,000
July 5, 1884	4,000
August 5, 1886	4,000
August 11, 1888	5,000
Total amount appropriated to June 30, 1890	16,000

The amount expended to June 30, 1889, was $15,768.99; $7,425 of which had been applied to the improvement of Tensas River, and $8,343.99 to Bayou Maçon. The obstructions were cleared as far as practicable with this amount, and in 1889 the master of the largest boat running in these streams stated that the trip from the mouth of Maçon to Floyd and return had been shortened twelve hours. The work is not permanent, however, as new obstructions are forming continually.

No work was done during the fiscal year ending June 30, 1890, as the balance available was too small to resume operations.

The New Orleans, Natchez and Fort Scott Railway Company (now called the New Orleans and Northwestern) obtained a charter for a bridge across Tensas River near Daniel's Ferry, Louisiana, by act approved March 1, 1889. (Chapter 312, laws of the United States.) Plans of the

bridge were received October 24; an examination of the proposed site, at Clayton's plantation near Daniel's Ferry, Concordia Parish, La., was made by Assistant Walter S. Davis early in November; and the maps, plans recommendations, etc., were forwarded to the Department November 9. Under date of December 19 the Secretary of War approved the plans and location of the proposed bridge, and directed that the engineer officer in charge of this district supervise its construction "so far as may be necessary in order that it may be built in accordance with the approved plans;" and to report to the Department at the proper time whether the bridge was so constructed.

This notice was received by me January 3, 1890, and on the same day I sent a certified copy of the approval of the plans and location by the Secretary of War to the president of the railway company, through the chief engineer of the construction company, writing as follows:

I have to inform you that I have this day received official notice through the Chief of Engineers, U. S. Army, of the approval of the Secretary of War of the plans of the bridge proposed by your company over Tensas River, Louisiana, near Daniel's Ferry, and that I have been appointed supervising engineer so far as is necessary to see that the approved plans are followed. I inclose a copy of the notice sent to me with the plans. You are hereby authorized to begin the construction of said bridge in accordance with the approved plans as soon as you find it necessary to do so. I will visit the work from time to time on request of your chief engineer, or when I deem it necessary, and will render an itemized account of my actual expenses incurred, which will be a proper charge for you to pay.

I received no answer or acknowledgment from any officer of the company, and I presumed that the extraordinary spring flood had prevented the commencement of the work. After waiting a reasonable time, when the water had fallen sufficiently for operations, I wrote to the chief engineer of the construction company, May 27, to ask if work had been commenced, and received a letter and tracing from him June 11, showing "the bridge as built." As soon as funds are available an examination of the site and construction will be ordered and a report made on the work; but for the present report, all that can be said is that the company failed to give notice to the district officer when construction was begun; neglected to inform him of the progress of the work; built a bridge without following the plans approved by the Secretary of War, and is now operating an apparently unlawful structure, to the injury of the navigation of Tensas River.

It is reported that one or more steam-boats have collided with the bridge or its approaches, and that the owners of the steam-boat *Shaw* have instituted suit for damages. Complaint has been made by steamboat men that the bridge is a serious impediment to the navigation of the stream, which will be investigated without delay.

With the amount asked for the fiscal year 1892, it is proposed to continue the work of removing snags and logs, cutting leaning timber, etc.

Money statement.

July 1, 1889, amount available	$231.01
July 1, 1890, amount expended during fiscal year, exclusive of liabilities outstanding July 1, 1889	104.25
July 1, 1890, balance available	126.76
Amount appropriated by act of September 19, 1890	5,000.00
Amount available for fiscal year ending June 30, 1891	5,126.76
Amount (estimated) required for completion of existing project	19,000.00
Amount that can be profitably expended in fiscal year ending June 30, 1892	10,000.00
Submitted in compliance with requirements of sections 2 of river and harbor acts of 1886 and 1887.	

COMMERCIAL STATISTICS.

Navigation in these streams was interrupted from May 20 to November 15. Steamers resumed business December 1, and there was good navigation for the larger boats from this time to the end of the fiscal year. In the Lower Tensas there was good navigation for the smaller boats the whole year. The commerce of these streams gave business to six steam-boats. These boats made a total of ninety-three trips during the season. There are one hundred and fifty regular freight landings on these streams.

Name.	Registered tonnage.	Draught.		Round trips.
		Light.	Loaded.	
		Ft. In.	Ft. In.	
H. J Dickey	208.54	3 0	7 0	17
Marcus Collins	48.14	1 0	3 0	33
L. Teal	27.52	1 2	3 0	33
H. W. Graves	31.22	1 2	3 0	8
*Cleon**	103.54	2 2	2 2	1
*Ida B. Cothell**	57.05	2 2	2 2	1

* Tow-boats.

Commerce.

	1888-'89.	1889-'90.
	Tons.	Tons.
Cotton	2,750	1,527
Cotton-seed	4,000	2,920
Hides and skins	5	2
Live-stock	225	.....
Staves	3,500	3,325
Sundries	1,823	50
Total down freights	12,303	7,824
Return freights	8,202	5,216
Total freights	20,505	13,040
Total value	$1,194,100	$742,390

Unusually short crops were reported from these rivers the past year.

The Vicksburg, Shreveport and Pacific Railroad crosses Bayou Maçon at Delhi, La., and Tensas River at Dallas, La. The New Orleans and Northwestern crosses Tensas near Daniel's Ferry, Concordia Parish, La.

W 9.

IMPROVEMENT OF BIG BLACK RIVER, MISSISSIPPI.

This stream rises in Webster County, Miss., flows in a general southwesterly direction and enters Mississippi River at Grand Gulf, 37 miles below Vicksburg, having a length estimated to be about 400 miles.

An examination was made by the United States in 1881 (pages 1565-1570, Report Chief of Engineers, 1882), and the project contemplated clearing a channel suitable for navigation at high stages by the removal of snags, logs, wrecks, leaning timber, etc., from Cox's Ferry to the mouth, about 130 miles, at an estimated cost of $32,000.

The following appropriations have been made:

By act of—	
July 5, 1884	$5,000
August 5, 1886	5,000

A chopping party removed the principal obstructions for a distance of about 75 miles above the mouth in 1884–'85. Nothing has been done since, as the act of 1886 required that no part of the appropriation should be used until the State of Mississippi caused the bridges south of the Vicksburg and Meridian Railroad to be so constructed as not to obstruct navigation.

The bridges referred to were the Louisville, New Orleans and Texas Railway Bridge, about 15 miles above the mouth; a county bridge at Ivanhoe Ferry, about 50 miles above the mouth, and a county bridge at Baldwin's Ferry, about 70 miles above the mouth. In addition to these, the bridge of the Vicksburg and Meridian Railroad (now the Alabama and Vicksburg Railway), about 40 miles below Cox's Ferry, forms an obstruction to navigation at all stages.

The following extract from my report of January 9, 1890, printed in House Ex. Doc. No. 216, Fifty-first Congress, first session, gives the latest information regarding this stream:

I have the honor to recommend that the act of August 5, 1886, relating to the improvement of Big Black River, Mississippi, be amended by the repeal of the proviso, which reads as follows:

"No part of this appropriation shall be used until the State of Mississippi shall have first caused the bridges over said stream south of the Vicksburg and Meridian Railroad to be so constructed as not to obstruct the navigation of said stream."

The legislature of the State passed an act during the last session, in 1888, requiring the Louisville, New Orleans and Texas Railway Company to change its fixed bridge, crossing Big Black River about 15 miles above the mouth, into a swing-bridge; omitting all reference to other bridges between it and the bridge of the Vicksburg and Meridian Railroad (see Report of Chief of Engineers for 1888, page 1357). The swing-bridge has been constructed according to plans submitted through me and approved by the Department, and was swung for the first time December 31, 1889, and is now advertised in the public prints as finished and ready for business. The Ivanhoe Bridge has been replaced by a ferry maintained at the expense of certain merchants of Vicksburg, and the only bridge remaining to obstruct navigation is that at the crossing called Baldwin's Ferry, about 25 miles, by river, below the Vicksburg and Meridian Railroad Bridge. This is a free bridge, built and maintained by the county, and is about 16 miles from Vicksburg on a fairly good road much traveled.

The county supervisors are unwilling to take down or alter the bridge, and I think their reasons sound. The State has not ordered them to do anything to the bridge; the expense would be a heavy burden on the county, which has small resources; and the road brings the merchants of Vicksburg more business the year round than the river is likely to do during the short time it would be navigable. My own opinion is that the greater part of the river freight would go down stream rather than turn northward to Vicksburg. A few weeks since I drove over the road with the supervisor in charge, and examined the bridge and the site, and found that the bridge could not be changed to a draw-bridge, but that a new bridge would have to be built, and that the rise and fall are such as to make it very difficult to run a ferry. The banks are so high that teams could not haul full loads in low water when the river would be closed to navigation.

With the restriction removed and with another appropriation of $5,000, I think the river could be put in excellent condition from the Baldwin's Bridge to the mouth in one working season. The district plant will furnish all the tools and outfit, and, with a liberal use of high explosives, no further work should be required for several years."

Money statement.

July 1, 1889, amount available	$5,000
July 1, 1890, balance available	5,000
Amount (estimated) required for completion of existing project	22,000
Amount that can be expended profitably in fiscal year ending June 30, 1892	5,000

Submitted in compliance with requirements of sections 2 of river and harbor acts of 1866 and 1867.

COMMERCIAL STATISTICS.

During the past fiscal year but one steamboat traversed this river; the *Josie D. Harkins* (73.12 tons, draught light 1 foot 3 inches, draught loaded 2 feet 9 inches, went up a distance of 65 miles, the latter part of February. This boat brought out 3,800 sacks of cotton seed, and 4,500 staves were floated out in flat-boats.

The Alabama and Vicksburg Railway crosses Big Black River on a fixed bridge at a point about 20 miles east of Vicksburg, and the Louisville, New Orleans and Texas Railroad crosses at Allen's Station on a swing-bridge, about 15 miles above the mouth.

W 10.

IMPROVEMENT OF YAZOO RIVER, MISSISSIPPI.

Yazoo River, about 173 miles long, is formed by the junction of Tallahatchee and Yallabusha rivers in Le Flore County, Mississippi, flows in a general southerly and then southwesterly direction, and enters Mississippi River 5 miles above Vicksburg.

An examination of wrecks of gun-boats, steamers, and other obstructions placed in the river during the war was made by the United States in 1873 (pages 483, 484, Report of Chief of Engineers, 1873), and a further examination was made in 1874 (pages 364–367, Report Chief of Engineers, 1874). The project contemplates the removal of wrecks, logs, snags, and leaning timber which obstruct navigation throughout the entire length of the river. New obstructions caused by floods, sliding banks, etc., are brought into the river every year, and no estimates have been made for permanent improvement on this account.

The following appropriations have been made:

Act of—	
March 3, 1873	$40,000
March 3, 1875	12,000
August 14, 1876	15,000
June 18, 1878	25,000
March 3, 1879	15,000
June 14, 1880	12,000
March 3, 1881	6,000
August 2, 1882	8,000
July 5, 1884	10,000
August 5, 1886	15,000
August 11, 1888	32,000
Total amount appropriated to June 30, 1890	190,000

The wrecks of 9 steam-boats, sunk during the war, were removed by contract in 1873–'74. Experience gained by this work showed that the improvement could be continued more economically by means of a snag-boat operated with hired labor, and in 1875 and 1877 the United States snag-boat *O. G. Wagner* was employed in removing wrecks and other obstructions. In 1879 the snag-boat *John R. Meigs* was completed, and the principal work since has been done with that boat. The amount expended to June 30, 1889, was $177,557.74.

In the past fiscal year operations were as follows:

The snag-boat *Meigs*, P. R. Starr, master, entered this river and resumed work October 3, continuing without cessation until November 8, when work was taken up in Tallahatchee River. The stage of the river was very low, not more than a foot above extreme low water during the greater portion of the time, exposing many of the obstructions to view and permitting effective work. The plan pursued was to remove

the most obstructive snags, stumps, etc., from the channel, proceeding up stream as rapidly as possible, so as to accomplish the greatest good before the water should rise. To have attempted thorough removal of all stumps, shore snags, and leaning trees would have exhausted the funds in a short stretch of river, with but little general benefit to navigation. Work was done at the following wrecks; Steam-launch *Greyhound* raised opposite Hayne's Bluff; boilers, shaft, wheel, and part of bow of burned steamer *Barksdale* removed from channel opposite Hendrick's Place; parts of wreck of steamer *Mary E. Keene* removed from channel at French Bend and sunken flat-boat from the bar above; and part of steamer *Williams* and a large flat-boat opposite Greenwood.

The following is a summary of the work:

	Number.
Snags pulled	400
Stumps removed	285
Logs removed from channel	47
Shore snags cut	73
Leaning trees cut	21
Wrecks removed	6

Since the return of the *Meigs* from Ouachita River in January the water has been too high for work, and the boat has been laid up in the lake at Vicksburg undergoing such minor repairs as could be made by the watchmen.

The pumping dredge-boat described in my report of last year was purchased and towed to Vicksburg in July, and the machinery, etc., has been overhauled and rearranged, and a larger pressure pump added. The dredge at present is laid up alongside the *Meigs*, and both boats are cared for with one force.

The amounts expended during the fiscal year were:

For general improvement, care of plant, etc	$4,235.64
For pumping dredge-boat	5,081.75

The appropriation for the general improvement of the river is practically exhausted, the funds available being from the allotment provided by act of August 11, 1888, "for constructing a pumping dredge-boat," all of which probably will be needed for additional machinery, fittings, hose, repairs of hull, etc.

The appropriation for this work should be large enough to permit the organization and equipment of chopping parties to cut leaning timber and clear caving and sliding banks, in addition to the operations of the snag-boat. This class of work can be done cheapest in this manner, and if carried out systematically will do much towards effecting a permanent improvement.

Clearing the banks for some distance back will diminish their tendency to slide, and the consequent formation of snags and drift; and clearing the points, especially in tortuous bends like the Ox-Bows, will not only give safer passage, but reduce the danger of collisions.

No expensive works in the way of dikes or locks and dams seem required for the present needs of commerce in this stream. The channel is fairly uniform in section, the banks generally above high water, except from overflows from Mississippi River, the danger of which is diminishing yearly, and there are few shoals, and these can be removed by dredging or building inexpensive wing-dams.

The principal obstruction is the shifting bar where Yazoo enters Mississippi River, which fills or scours as the ratio of discharge of the two rivers, which may be represented by $\frac{Y}{M}$, diminishes or increases. With

Mississippi River in flood and Yazoo draining its own valley or falling, the lower portion of the smaller stream is filled with backwater, which leaves a thick deposit of sand and mud to be washed away as the larger river falls. Last season, with 8 feet on the Mississippi gauge, boats drawing 30 inches could not cross the bar at the mouth of Yazoo, except by pulling over with lines and capstans. The channel was crooked, narrow, and shoal, passing between banks of sand some eight feet above water, which had been deposited during the preceding flood. The same thing happens every year; but the degree of obstruction caused by the deposit varies considerably. If Mississippi falls rapidly and remains low for some time, the channel through the bar improves rapidly, and the more so if the Yazoo Valley receives much rain.

The relative direction of flow of both rivers at their junction is such as to form this bar in every flood and to warrant the opinion that no works can be built to keep a channel through it at all stages for the boats now engaged in navigating Yazoo River and its tributaries; and with the development of the Yazoo Valley boats of greater tonnage will be required.

Congress has appropriated considerable money for improving the principal streams forming this Yazoo Valley system of inland navigation of about 900 miles, and the settlement of this part of the country has been due in no small degree to the improved facilities for getting supplies and moving crops.

Increased security against destructive overflows from Mississippi River is drawing planters and small farmers from the hill country into this fertile valley, and railroads are penetrating it in all directions to win part of its growing trade.

Liberal appropriations for one or two years, to allow systematic continuous work, would stimulate the settling of the valley and bring large returns to the people, but, until the problem of deep water at the entrance to the system is solved, no great increase of river business can be expected. The depth at the mouth should always be greater than the maximum depth that can be made for the passage of the farthest shoals in the upper river by such boats as are needed for the trade. Ordinarily this might be obtained by jetties or fixed by the depth on miter sill of a lock. In the case in hand it is not probable that jetties costing $1,000,000 would maintain the required depth for more than two or three years, and a lock and dam at the present mouth is out of the question. Moreover, as an open river that would give a navigable depth of at least 4 feet, even with occasional detentions, is to be preferred to a canalized river of, say, 5 feet with detentions at every lock, it would seem proper to inquire if Yazoo River may not be diverted and brought to the Mississippi by some shorter route, at a reasonable cost, and so gain sufficient depth of water at the entrance to the system at all stages.

The plan of turning Mississippi River back of Paw Paw Island has been suggested, but it could not be done well without great expense, must be uncertain in its result, and in my opinion would not afford permanent relief, but only shift the bar farther up-stream.

I believe, however, that it is practicable to change the course of the Yazoo River by Chickasaw Bayou or Old River so as to empty into Centennial Lake and pass the city front of Vicksburg along the old channel of the Mississippi, debouching at Kleinston, and thus give good navigation into the Yazoo system the year round and maintain a deep-water harbor for the city.

An extended survey of Yazoo River would not be needed, but only a reconnaissance of the upper river with discharge measurements, chan-

nel soundings, and sections at the bars, and a thorough examination of the river, and land between it and the lake, for about 20 miles above Vicksburg, to get data for a definite line and plan of improvement, and estimates of its cost.

The reconnaissance can be made for about $2,500, and the survey of the lower part, which will require extensive borings on several trial lines, can be made for about $5,000. About $500 would be needed for gauges at Greenwood, Tchula Lake, Big Sunflower River, or at such places as should be found convenient.

A small light-draught steam-boat, with shears or a crane and hoisting engines or capstans, is much needed for the upper Yazoo and for the smaller streams of this district east of the Mississippi. At present it is necessary to charter, and it is difficult to find boats suitable for the purpose, and the lowest charter price that has been obtained exceeds the cost of running the *Meigs*. The *Meigs* can be used to advantage for about five months of the year, and then, if not needed in Red or Ouachita, should be laid up at Vicksburg.

The following are the estimates for the fiscal year ending June 30, 1892:

Snag-boat *Meigs*:	
Five months' service, at $2,500	$12,500
Seven months in ordinary, at $250	1,750
Pumping dredge:	
Three months' service, at $800	2,400
Nine months in ordinary, at $75	675
Flat-boats and outfits and expenses of chopping parties engaged in systematically clearing the banks	12,000
A small light-draught boat for use in the upper river and the tributaries to Yazoo	10,000
Eight months' service of light-draught boat, at $1,000	8,000
General repairs of plant and outfit, office expenses, and contingencies	4,675
Examinations and surveys	8,000
Total	60,000

Money statement.

July 1, 1889, amount available		$12,442.26
July 1, 1890, amount expended during fiscal year, exclusive of liabilities outstanding July 1, 1889	$9,317.39	
July 1, 1890, outstanding liabilities	.34	
		9,317.73
July 1, 1890, balance available		3,124.53
Amount appropriated by act of September 19, 1890		25,000.00
Amount available for fiscal year ending June 30, 1891		28,124.53
Amount that can be profitably expended in fiscal year ending June 30, 1892 Submitted in compliance with requirements of sections 2 of river and harbor acts of 1866 and 1867.		60,000.00

COMMERCIAL STATISTICS.

There was navigation in this river the year round, but it was interrupted about two months by the bar at the mouth.

Eleven steam-boats made a total of four hundred and thirty-three round trips in Yazoo and Tallahatchee rivers and Tchula Lake. The Big Sunflower boats traversed Yazoo River for about 50 miles, and eight steamers made a total of one hundred and forty-four round trips in that stream.

Steam-boats running in Yazoo and Tallahatchee rivers and Tchula Lake.

Name.	Registered tonnage.	Draught.		Round trips.
		Light.	Loaded.	
		Ft. In.	Ft. In.	
Blanks Cornwall	232.04	1 10	4 0	39
Katie Robbins	162.54	1 8	4 0	21
Mountain Girl	134.30	1 6	3 0	33
R. L. Cobb	204.56	1 6	3 0	12
Birdie Bailey	109.74	1 6	3 0	72
John F. Allen	133.90	1 4	4 0	78
Ike Bonham	78.52	1 10	3 0	57
New Evergreen	22.62	1 3	2 6	33
Lake City	35.20	1 5	2 6	33
Addie E. Faison	241.50	1 6	4 6	31
Crown Point	235.20	2 0	4 6	24

Commerce.

	1889–'90.
	Tons.
Cotton	11,382
Cotton seed	12,987
Hides and skins	10
Live stock	55
Lumber	1,599
Staves	1,262
Total down freights	27,295
Return freights	18,198
Sunflower freights	18,160
Total freights	63,653
Value of Yazoo freights	$8,699,966
Value of Sunflower freights	$1,220,070
Total value	$9,920,036

In addition to the above, there was rafted out of the Yazoo River 900,000 feet of hewn oak timber and 15,000 cypress logs.

The cotton crop of Yazoo River and tributaries is said to be, in round numbers, 105,000 bales. No reliable estimates for the preceding year could be obtained, so that no comparison could be made.

The Georgia Pacific Railway, from Greenville to Starkville, Miss., crosses Yazoo River and enters Greenwood, Miss. A branch of the Illinois Central Railroad, beginning at Parsons, on Yallabusha River, touches Yazoo River at Greenwood, Tchula, Yazoo City, and other points, joining the main line at Jackson, Miss. This road has a branch from Tchula to the main line at Durant, Miss. A branch of the Louisville, New Orleans and Texas Railroad is now under construction, which will be completed in time to carry off a portion of present crop. It starts at Clarksdale and runs down Cassidy Bayou to Minter City, on the Tallahatchee River. It will affect all the country along the Tallahatchee northward to point where it branches off to Castor Bayou.

W 11.

IMPROVEMENT OF TCHULA LAKE, MISSISSIPPI.

Tchula Lake, or River, is the East Branch of Yazoo River where it divides in passing Honey Island, and is about 60 miles long. Honey Island is about 100 miles above the mouth of Yazoo River. Fertile plantations join one another along the banks of the lake, and their annual product is estimated to be about 20,000 bales of cotton.

An examination was made by the United States in 1879 (pages 1350, 1351, Report Chief of Engineers, 1880,) and the project based thereon contemplated the removal of snags, logs, and overhanging trees, so as to allow light-draught boats to enter the lake earlier in the season; the work to be completed in one low-water season, at an estimated cost of $10,000.

The appropriations have been as follows:

Act of—	
March 3, 1881	$3,000
August 2, 1882	2,500
July 5, 1884	1,500
August 5, 1886	2,000
August 11, 1888	3,000
Total amount appropriated to June 30, 1890	12,000

The amount expended to June 30, 1889, was $10,278.57.

Work was commenced in 1881, and continued in 1882, 1884, 1886–'87, and 1889, and the obstructions were removed as far as practicable with the amounts appropriated.

No work was done in the past fiscal year, as a favorable opportunity for the advantageous expenditure of the available balance was not presented.

The work is of such nature that it must be gone over from time to time to remove obstructions that are forming continually, but by the expenditure of $6,000 in one low-water season the obstructions can be removed so thoroughly that further work will not be needed for several years.

Money statement.

July 1, 1889, amount available	1,721.43
July 1, 1890, balance available	1,721.43
Amount appropriated by act of September 19, 1890	3,000.00
Amount available for fiscal year ending June 30, 1891	4,721.43
Amount that can be profitably expended in fiscal year ending June 30 1892 Submitted in compliance with requirements of sections 2 of river and harbor acts of 1866 and 1867.	6,000.00

COMMERCIAL STATISTICS.

When the water is high enough Yazoo River steam-boats run through the lake, but no data of the amount of business to be accredited to that stream could be obtained, as the boats do not separate it from their records for Yazoo and Tallahatchee rivers.

W 12.

IMPROVEMENT OF TALLAHATCHEE RIVER, MISSISSIPPI.

The headquarters of this river are in Tippah County, in northern Mississippi, whence it flows in a general southwesterly direction through the counties of Union, La Fayette, Panola, joins Coldwater River in Quitman, and then, as the main stream, flows in a southerly direction through Tallahatchee and Le Flore counties, and unites with Yallabusha in forming Yazoo River.

An examination was made by the United States in 1879 (pages 982–986, Report Chief of Engineers, 1879). The project based thereon contemplated the removal of snags, sunken logs, and leaning timber obstructing low-water navigation below the mouth of Coldwater, a distance of 165 miles, and the wreck of the steamer *Star of the West*, 8 miles above the mouth, at an estimated cost of $40,000. An additional examination was made in 1880 (pages 1322–1323 Report Chief of Engineers, 1880), which showed that any improvement above Sharkey's Landing, 100 miles above the mouth, would be of little benefit. Below that point the work is important, as at present the river is the most available outlet to market, the only other means of transportation being the branch of the Illinois Central Railroad east of Yallabusha River, which is practically inaccessible to planters on the right bank and would necessitate a haul of from 5 to 25 miles through swamps and across Yallabusha for those on the left.

The following appropriations have been made for this work:

By act of—	
March 3, 1879	$6,000
June 14, 1880	9,000
March 3, 1881	3,000
August 2, 1882	3,000
July 5, 1884	3,000
August 5, 1886	3,500
August 11, 1888	5,000
Total appropriated to June 30, 1890	32,500

Work was begun in 1879 and continued in 1880, 1881, 1882, 1884, 1886, 1887, and 1889. Parts of the appropriations of 1880 and 1881 and all of the appropriation of 1882 (a total of $10,000) were expended above mouth of Coldwater to Batesville, as required by the acts, but this part of the river was not included in the original project or estimate of cost. All other work has been confined to the stretch of river below Sharkey's, and has resulted in the removal of a large number of obstructions and greatly increased the capacity of the river for navigation. Before the improvement commenced the river was navigable about six months of the year. Boats now run to Sharkey's Landing the entire year.

In the past fiscal year operations were as follows: The snag-boat *Meigs*, P. R. Starr, master, entered this stream and commenced work November 8, and continued same until December 24, when the available funds were exhausted. Channel work was carried upstream to the mouth of Cassidy's Bayou, 1 mile below Sharkey's. No work being required above that point, the boat turned back and commenced the removal of the worst leaning trees, girdling others liable to prove obstructive. This work was completed December 7, after which the snag-boat went over the lower 90 miles of the river again, removing channel and shore snags and other obstructions to low-water navigation. The wreck of the steamer *Star of the West* was more exposed than at any time when the snag-boat has been in this river before, and by the help of high explosives it was removed down even with the bed of the stream, and also a part of the rebel raft placed in the channel in 1863, when the steamer was sunk, resulting in a good channel 4 feet deep and over 100 feet wide. Part of the wreck remains, buried several feet in the sand, and in case the bottom should continue to scour its thorough removal will be necessary. At the request of the general manager of the Yazoo and Tallahatchee Transportation Company and the agent of the underwriters, assistance was rendered by the *Meigs* November 11 in pumping

out the sunken steamer *John F. Allen*, near Shell Mound, and after three hours' work the boat was raised.

The following is a summary of the work done:

	Number.
Snags pulled	332
Stumps pulled	32
Logs removed from channel	59
Shore snags cut	769
Leaning trees cut	2,148
Trees girdled	10,065
Square yards willows and brush cut	435
Wrecks removed (the greater part of steamer *Star of the West* from stern-post to midship, sunken steamer *John F. Allen*, and shaft and three flanges of steamer *Hartford City*)	3

There is no doubt that this work benefited navigation greatly, but much remains to be done before any permanent effect will be obtained. New obstructions are forming continually, as is shown by the following extract from the report of P. R. Starr, master of the snag-boat *Meigs*:

The river is timbered on both banks almost its entire length, the growth consisting principally of oak, hickory, pecan, gum, sycamore, and cypress, nearly all of which will sink when green. Many of the trees are in the water and others project far out from the banks. The banks are soft and sandy, and undermined with innumerable small springs. The trees slide and cave into the stream, becoming dangerous obstructions. Planters in clearing the banks allow many of the trees to fall into the river and make no effort to remove them. Raftsmen lose many of their logs, which either become floating butts or are stranded upon the bars, and I have observed that no matter how thoroughly a bar is cleared of obstructions additional ones can be found upon it in a very short time, the shifting and scouring of the channel exposing them constantly to the action of the current. No permanent good can be accomplished until the trees liable to fall or slide into the river are removed, and until this is done snag-boats can do little more than make trips over the river and remove whatever may have become dangerous obstructions. In the past season we have girdled or deadened over ten thousand of the trees most liable to fall or slide into the river, and the river men and planters, with one or two exceptions, express themselves as well pleased with the work accomplished.

The great trouble has been that the small amounts of the appropriations prevented attempting any work beyond the removal of the worst obstructions. Major Benyaurd, in submitting the project for this improvement (page 985, Report Chief of Engineers, 1879), estimated that it would take two seasons' work at a cost of $40,000. The appropriations to the present time aggregate $32,500, $10,000 of which had to be spent in a part of the stream not included in the project. Future work should be confined to the river below Sharkey's. Steam-boats do not go above that landing, except to make occasional trips into Coldwater River, during the high stages, and then navigation is as good and about as safe as in the lower part of the stream. It is useless to expend any more money above the Coldwater. There is no commerce in that part of the stream, and even if it were improved I doubt if boats could be induced to run there. The snag-boat *Meigs* should be used a short time each year to remove heavy snags, tree slides, and sunken saw-logs, but the appropriation should be large enough to permit the systematic clearing of the banks by shore parties, and $10,000 can be expended to advantage in the fiscal year 1892.

Money statement.

July 1, 1889, amount available	$2,951.89
July 1, 1890, amount expended during fiscal year, exclusive of liabilities outstanding July 1, 1889	2,951.89
Amount appropriated by act of September 19, 1890	5,000.00

Amount (estimated) required for completion of existing project	$12,500.00
Amount that can be profitably expended in fiscal year ending June 30, 1892	10,000.00
Submitted in compliance with requirements of sections 2 of river and harbor acts of 1866 and 1867.	

COMMERCIAL STATISTICS.

The Yazoo River steam-boats run as high as Sharkey's Landing, on this river, 100 miles above its mouth, but keep no separate record of its business, and it was impossible to obtain any data regarding same, except that the crop was estimated at 20,000 bales of cotton, all of which was shipped by river.

W 13.

IMPROVEMENT OF STEELE'S BAYOU, MISSISSIPPI.

This bayou has its source in Swan Lake, Washington County, Miss.; flows in a southerly direction, parallel to Mississippi River, and enters the Yazoo about 12 miles above its mouth. The stream is about 85 miles long, and generally is not navigable except when the Mississippi is high enough to fill the lower portion with backwater.

An examination was made by the United States in 1883 (pages 1360–1362, Report Chief of Engineers, 1884), and the officer in charge reported the stream not worthy of improvement and the work not a public necessity.

The following appropriations have been made for this work:

By act of—	
July 5, 1884	$2,500
August 5, 1886	2,500
August 11, 1888	2,500
Total appropriated to June 30, 1890	7,500

Chopping parties removed snags, stumps, leaning timber, etc., during 1884–'85 and the latter part of 1886, and in February, 1889, a steamer was employed to go over the work and remove the heavier obstructions. Operations have extended from the head of Washington Bayou, which connects Steele's Bayou and Lake Washington to the mouth of Steele's Bayou, but were by no means thorough, on account of the small appropriations.

In the past fiscal year operations were as follows: A light-draught steamer was employed for six days, July 12–17, in removing obstructions from the lower part of the bayou. Work was commenced at Bon Eagle Plantation and carried down-stream to the mouth, a distance of 22 miles. The following obstructions were removed:

	Number.
Stumps removed from channel	2
Logs removed from channel	2
Jams removed	2
Side jams removed	1
Leaning trees cut	142

The region bordering the upper part of the bayou and Washington and Swan lakes furnishes the principal products. The lower part is subject to overflow, and not much land in the vicinity is cultivated. The west side of Lake Washington is near the Mississippi, and a branch of the Louisville, New Orleans and Texas Railroad from Greenville to

Rolling Fork, between Swan Lake and Lake Washington, has diverted the main traffic from the bayou; in fact there has been but little navigation of the stream for several years.

If the improvement is to be continued, it is recommended that the appropriation be large enough to clear the stream of obstructions so thoroughly that further work will not be needed, at least for many years to come. The sum of $5,000 could be spent to advantage in one low-water season in opening the bayou for high-water navigation.

Money statement.

July 1, 1889, amount available	$670.65
July 1, 1890, amount expended during fiscal year, exclusive of liabilities outstanding July 1, 1889	670.65
Amount appropriated by act of September 19, 1890	2,500.00
Amount that can be profitably expended in fiscal year ending June 30, 1892 Submitted in compliance with requirements of sections 2 of river and harbor acts of 1866 and 1867.	5,000.00

COMMERCIAL STATISTICS.

There was no navigation in this stream during the past fiscal year until the high-water season. After the levee broke at Mayersville two small steam-boats began trips through the bayou.

The river-side division of the Louisville, New Orleans and Texas Railroad has diverted all the trade above the bayou, on which the boats depended principally.

Name.	Registered tonnage.	Draft				Round trips.
		Light.		Loaded.		
		Ft.	In.	Ft.	In.	
Lake City	78.52	1	5	2	6	4
Ike Bonham	44.00	1	10	3	0	10

*Commerce, 1889-'90.**

Cotton	tons..	8
Cotton seed	do...	346
Total down freights	do...	354
Return freights	do...	350
Total freights	do...	704
Total value		$50,000

*No boats ran in the bayou in 1888-'89.

W 14.

IMPROVEMENT OF BIG SUNFLOWER RIVER, MISSISSIPPI.

This river has its source in Moon Lake, Coahoma County, Miss.; flows in a southerly direction and enters Yazoo River about 45 miles above its mouth. During extreme high water it is navigable to Clarksdale, 280 miles above the mouth, but Faisonia, 144 miles above the mouth, ordinarily is considered the head of navigation.

An examination was made by the United States in 1878 (pages 982-

984, Report Chief of Engineers, 1889), and the plan adopted for the improvement contemplated building timber and brush dams at the shoals to scour a channel 3 feet to 40 inches deep, and the removal of snags, sunken logs, and leaning timber obstructing navigation, at an estimated cost of $66,000.

The following appropriations have been made:

By act of—	
March 3, 1879	$20,000
June 14, 1880	8,000
March 3, 1881	4,000
August 2, 1882	5,000
July 5, 1884	5,000
August 5, 1886	5,000
August 11, 1888	5,000
Total appropriated to June 30, 1890	52,000

Work was commenced in 1879, and continued in 1880, 1881, 1882–'83, 1884, 1887, and 1889. Operations extended over the navigable portion of the stream, from Clarksdale to its mouth, but much remains to be done, and new obstructions are added every year.

In the past fiscal year operations were as follows: Work with the hired steamer *Addie E. Faison*, begun in June, was continued until July 7, when it was stopped by high water. By the 1st of September the river reached a stage low enough to resume work, and the steamer commenced operations at Oliphant's Bar on that date. Two wing-dams were built, one 176 feet and the other 144 feet long, resulting in an immediate increase of 1½ feet depth in the channel. The boat then worked up to McCormack's Crossing, where it was necessary to construct three wing-dams, 216, 176, and 37 feet long respectively, the river being very wide and shallow at this point. These increased the channel depth 2½ feet before the steamer left that vicinity. A wing-dam 64 feet long was then built at Fair View, September 9, on completion of which work was stopped for lack of funds.

The following is a summary of the work done:

	Number.
Wing-dams built (aggregating 813 feet in length)	6
Stumps removed from channel	4
Logs removed from channel	11
Leaning trees cut	5

The following information of benefits derived from work done in this river is taken from a letter of George W. Bookout, master of the steamer *Nellie Hudson*, dated April 13, 1890:

Before the improvement of Sunflower River was begun (in 1879) the river was navigable for very light boats about six months in the year. The river at the present time is navigable the year round, but with difficulty about three months of the time. Much larger boats can be used now, and can make the round trip (of about 180 miles and return) in five days. Before the improvement it was something unusual for a boat to make the trip under eight days. Insurance has been lowered considerably, perhaps 20 or 25 per cent., and rates of freight have been lowered a little more than 50 per cent. Sunflower River is improving very rapidly in the way of settlements along the banks, plantations being cleared up all along the river where a few years ago it was a wilderness. Of course part of this is attributable to the river improvement enabling boats to make quick and regular trips.

Of late years appropriations have been too small to accomplish permanent benefit, and the acts of 1886 and 1888 required that two-fifths of the amounts appropriated should be expended between Woodburn and Lehrton (about 80 to 120 miles above the mouth), leaving but $6,000 to be expended in the last six years in the lower part of the stream where work is most needed. The people engaged in business on this river want immediate relief and work of more lasting character than

that of the past, and $14,000 can be spent to great advantage in a single season in removing logs from the channel, building and repairing wing-dams, and cutting leaning timber. If no restriction is made as to where the funds shall be applied, the money can be spent where it will result in greatest benefit to navigation and commerce.

Money statement.

July 1, 1889, amount available	$1,756.27
July 1, 1890, amount expended during fiscal year, exclusive of liabilities outstanding July 1, 1889	1,756.27
Amount appropriated by act of September 19, 1890	5,000.00
Amount (estimated) required for completion of existing project	9,000.00
Amount that can be profitably expended in fiscal year ending June 30, 1892	9,000.00
Submitted in compliance with requirements of sections 2 of river and harbor acts of 1866 and 1867.	

COMMERCIAL STATISTICS.

During the past fiscal year the river was navigable the whole year to Woodburn, 115 miles above the mouth, and for seven months to Faisonia, 144 miles above the mouth.

Steam-boats navigating the Big Sunflower, 1889–'90.

Name.	Registered tonnage.	Draught. Light.		Draught. Loaded.		Round trips.
		Ft.	In.	Ft.	In.	
Nellie Hudson	213.31	1	4	3	0	25
Addie E. Faison	241.50	1	6	4	6	11
Josie D. Harkins	73.12	1	3	2	9	20
Mountain Girl	134.30	1	6	3	0	5
Sarah E. Elliott	49.01	1	6	2	6	3
Ike Bonham	78.52	1	6	3	6	52
Hill City	90.00	1	4	4	0	18
Lake City	44.00	1	5	3	0	10

Commerce.

Articles.	1888–'89.	1889–'90.
	Tons.	*Tons.*
Cotton	4,000	2,594
Cotton-seed	6,000	3,975
Hides and skins	1½	.....
Live-stock	150	150
Lumber	.....	839
Staves	490	5,250
Sundries	3,880	.....
Total down freights	14,521½	12,838
Return freights	9,680	5,322
Total freights	24,201½	18,160
Total values	$1,858,246	$1,220,070

In addition to the above, 4,000 cypress logs were floated out.

The estimates for 1888–'89 evidently were excessive, as there was nothing to cause a decrease in the commerce during the past fiscal year.

The Georgia Pacific Railway crosses the river at Johnsonville, and the Louisiana, New Orleans and Texas Railroad touches at Clarksdale, and thence south runs parallel ot the stream, at distances varying from 5 to 20 miles. It is reported that these oads transported about 10,000 bales of cotton from the Sunflower River country.

W 15.

IMPROVEMENT OF BIG HATCHEE RIVER, TENNESSEE.

This river has its source in northern Mississippi, flows in a northwesterly and then westerly direction, through the most productive region of West Tennessee, and enters Mississippi River 50 miles above Memphis. About 1858 the State of Tennessee appropriated $32,000 for improving the river, the expenditure of which placed the stream in navigable condition, and considerable business was done upon it, from six to seven steam-boats being employed during the cotton season, and navigation was open the year round for light-draught boats. In 1866 the legislature of Tennessee declared it an unnavigable stream, authorizing certain railroads to bridge the river, and navigation was suspended until 1879, when the law was repealed and the bridges were altered.

An examination was made by the United States in 1879 (pages 1330–1332, Report Chief of Engineers, 1880), and the project based thereon contemplated the removal of logs, snags, leaning timber, etc., obstructing navigation from Bolivar, Tenn., to the mouth, estimated to be about 240 miles, to render the river navigable for light-draught steam-boats throughout the year. The estimates were based upon a plan for completing the work in *three* seasons, at a cost of $30,000.

The appropriations have been as follows:

By act of—	
June 4, 1880	$10,000
March 3, 1881	3,500
August 2, 1882	3,000
July 5, 1884	2,500
August 5, 1886	3,000
August 11, 1888	5,000
Total amount appropriated (in ten years)	27,000

In view of the above, and the fact that new obstructions are added from time to time, it will be impossible to complete the work within the original estimates, or to give any definite estimate of its final cost.

Work was begun in 1880 and continued in 1881, 1882, 1884, 1886–'87, and 1889. Before its commencement navigation was suspended virtually by reason of the obstructions formed since 1866. In 1889 it was navigable for seven months, and the work benefited commerce in allowing river competition where railroads had monopolized the trade before.

In the past fiscal year operations were as follows: The hand-propelled snag-boat which had been used in Forked Deer River was repaired and towed to the mouth of Big Hatchee, where work was commenced August 19, and carried up-stream 57 miles to Rialto, operations having been suspended at the latter place October 31. With the exception of eleven days in September, when a sudden rise necessitated a suspension, the river was at a low stage, and effective work was done. As this part of the river was worked over by a shore party in 1887, operations of the past season were confined almost exclusively to the channel, which was much obstructed by sunken logs. High explosives were used successfully in removing obstructions too heavy for the snag-boat, and the work resulted in clearing a good channel 30 to 50 feet wide and 2 to 2½ feet deep at the shoal places, the snag-boat, drawing 2 feet, passing up easily.

The following is a summary of the work:

	Number.
Snags and logs removed from channel	728
Stumps removed from channel	143
Side jams removed	143
Shore snags cut	393
Leaning trees cut	217
Leaning trees topped	17
Trees girdled	2,322
Square yards willows and brush cut	375

The pile-driver barge lent by Captain Leachin 1888 and fitted up as a snag-boat for use in this and Forked Deer River, was returned to the fleet at Plum Point, Tenn., December 5, 1889. The cost of repairing and returning the boat used up the small balance of the appropriation.

Extracts are given below from the report of Overseer J. T. Dorey who superintended the work:

The river now is in good condition for light-draught boats from the mouth to Rialto. This being the first snagging done, however, it is not probable that it has cleared the stream of obstructions permanently, as logs were removed which formed the key to a mass of sunken timber which will rise to the surface each high water, and render snagging operations necessary for several successive seasons.

The course of the river is more tortuous than usual in streams of its kind, consisting of a continuous series of loops, the bends almost invariably being narrower at the neck than at the point, and in a direct line the distance from Rialto to the mouth is less than 18 miles, while by river it is 57 miles.

The banks are subject to overflow for a distance of one-half to 2 miles on each side, and are covered by a growth of large timber, principally hard woods, such as oak and hickory. Beyond the bottoms, the country is thickly settled and well cultivated.

There is some prospect of a steam-boat entering the trade between Rialto and Memphis in the interest of the Covington Compress Company and the merchants of that place. This is the only project likely to advance the commercial importance of Big Hatchee at present. There has not been sufficient commerce on the stream this year, either by steam-boats or timber interests, to justify any extensive improvement, and it remains to be seen whether the work done will increase the traffic. From the mouth to Bolivar the river is crossed by four railroads, from 50 to 60 miles apart, which always will transport most of the products of the country. The only advantage of river transportation will be to act as a check upon the railroads and prevent exorbitant charges for freights.

I recommend that the river below Rialto be improved thoroughly first, as it is the most important part of the stream, and its improvement will be of more advantage to the country as an outlet for shipping. In connection with this work, shore-work might be done from Brownsville to Bolivar, to facilitate the passage of stave barges and timber rafts, that being the only portion of the stream that has not been cleared of leaning timber. A boat with steam power, similar to that used the past season, and a liberal supply of dynamite, with axes and saws for the shore party, will do all the work necessary, as the funds can be spent judiciously only when the water is low.

If this work is to be continued, economy will be subserved by expending in one season an amount sufficient to clear the river so that further work shall not be required for several years. The improvement will be much more thorough and lasting by such concentration, and the practical benefit to navigation more nearly attained. I recommend the expenditure of not less than $10,000 in one season, beginning work as soon as the stage of water will permit, constructing or hiring a flat-boat with steam capstan, and using explosives liberally for removing snags and sunken logs. A shore party, lodged in tents and moving about in skiffs, should clear the banks of brush and leaning timber, and supplement work in the channel or join the flat-boat party when the water is low. Experience in the past shows that little benefit can be derived from small and irregular allotments; the cost of administration is increased, and much of the good results of the work is lost in the interval between appropriations.

COMMERCIAL STATISTICS.

No information could be obtained of the commerce of this stream.

Money statement.

July 1, 1889, amount available		$3,010.98
July 1, 1890, amount expended during fiscal year, exclusive of liabilities outstanding July 1, 1889	$3,010.17	
July 1, 1890, outstanding liabilities	.38	
		3,010.55
July 1, 1890, balance available		.43
Amount appropriated by act of September 19, 1890		5,000.00
Amount available for fiscal year ending June 30, 1891		5,000.43
Amount that can be profitably expended in fiscal year ending June 30, 1892 Submitted in compliance with requirements of sections 2 of river and harbor acts of 1866 and 1867.		10,000.00

W 16.

IMPROVEMENT OF FORKED DEER RIVER, TENNESSEE.

Forked Deer River, 24 miles long, is formed by the North and South Forks, about 9 miles below Dyersburgh, flows in a southwesterly direction, enters Obion River 4 miles above its mouth, and thus finds an outlet to the Mississippi. Originally the mouth of the stream was at Ashport, but about fifty-one years ago the State of Tennessee cut a canal through to the Mississippi (now Obion River) shortening the length of the main Forked Deer River about one-half. The part below the canal to Ashport is called "Old" and "Lost" channels, and is blocked with snags and drift. The canal is known commonly as "Tigertail." North Fork is formed by several small creeks near Trenton, in Gibson County, flows in a westerly direction to Dyersburgh, thence southwesterly. South Fork heads in McNairy and Henderson counties and flows in a general northwesterly direction. Appropriations aggregating $43,000 were made at various times by the State of Tennessee, but their expenditure resulted in little or no benefit.

Examinations were made by the United States in 1874, 1880, and 1887, (Reports Chief of Engineers 1874, pages 372–380; 1881, pages 1489–1497; and 1887, pages 1494–1495). The project contemplated the removal of snags, logs, leaning timber, etc., in South Fork below Jackson, North Fork below Dyersburgh, and the main river. The estimates were $19,250, $4,500, and $7,000 for these branches respectively, but as they were based on plans for completing the work in one season, it is probable that the cost will be increased, as new obstructions are added from time to time.

The following appropriations have been made:

By act of—	
August 2, 1882	$3,000
July 5, 1884	2,000
August 5, 1886	5,000
August 11, 1888	9,500
Amount appropriated to June 30, 1890	19,500

All the appropriations prior to the act of 1888 were for the improvement of South Fork. Work in this branch was commenced in 1883, and

continued in 1884, 1886–'87, and 1888–'89. Its commerce consists chiefly of staves and lumber, brought out on flat-boats, and rafts of saw-logs. Before the improvement commenced about one boat in three was lost by reason of the obstructions. Now they make the trip with comparative safety and at considerable less cost.

Work in North Fork and the main river was carried on in the fiscal year 1888–'89. The former was put in fairly good navigable condition below Dyersburgh, but high water and the limited amount available prevented any material improvement of the main stream.

In the fiscal year 1889–'90 operations were continued under the superintendence of J. T. Dorey, as follows:

Work with the snag-boat and a shore party was resumed in the main river July 1, and continued down-stream to the mouth, which was reached July 31. All snags in sight were removed, and the following points noted for their obstructed condition were cleared as thoroughly as practicable, viz, Six-Mile Cut-off, Upper and Lower Hickory Landings, Skipper Cut-off and just above, Miller's Cut-off, and Tigertail Bar. The stage of water was too high to permit the removal of a number of stumps obstructing the channel below White Oak Landing, which were not removed until the latter part of October, after which, work in the main river was stopped.

The following summary shows the work done:

	Number.
Snags and logs removed from channel	184
Stumps removed from channel	90
Side-jams removed	9
Shore snags cut	251
Leaning trees cut	438
Leaning trees topped	37
Trees girdled	1,948
Square yards brush and willows cut	475

Excessively warm weather and the prevalence of malaria in the low swampy bottoms caused considerable sickness among the men, and delayed the progress of the work.

Work in North Fork was resumed November 1, and continued until November 23. Operations extended from the mouth up to Highland Cut-off, 7½ miles. It was found that the channel had scoured considerably since work stopped in May, 1889, was well defined, with caving banks at but few places. Wherever there were evidences of caving, the banks were cleared of timber for some distance back from the stream. Many logs and stumps had washed loose, and were removed easily.

The following is a summary of the work done:

	Number.
Snags and logs removed from channel	281
Stumps removed from channel	81
Shore snags cut	160
Leaning trees cut	125
Trees girdled	91

The acts making appropriations for this improvement required expenditure of amounts as follows:

South Fork	$12,500
North Fork	4,500
Main river	2,500
Total expended to June 30, 1890	19,500

South Fork is obstructed by numerous bridges which render steamboat navigation impracticable, and for the present no additional funds are required for its further improvement. The project for improving

North Fork, below Dyersburgh, is completed, and further work should not be required in it for several years, or at least not until the main river is put in equally good condition. For the latter purpose $5,000 can be expended to advantage in the fiscal year 1892.

COMMERCIAL STATISTICS.

No information could be obtained of the commerce of this stream.

Money statement.

July 1, 1889, amount available	$1,520.79
July 1, 1890, amount expended during fiscal year, exclusive of liabilities outstanding July 1, 1889	1,520.79
Amount appropriated by act of September 19, 1890	2,500.00
Amount that can profitably expended in fiscal year ending June 30, 1892 Submitted in compliance with requirements of sections 2 of river and harbor acts of 1866 and 1867.	5,000.00

W 17.

WATER-GAUGES ON THE MISSISSIPPI RIVER AND ITS PRINCIPAL TRIBUTARIES.

These gauges were designed to secure information from continuous records, with a view to protecting the alluvial basin of the Mississippi against overflow, improving navigation, and giving reliable reports for the benefit of river men and planters. They were established under joint resolution of Congress (Section 5252, Revised Statutes), viz:

SEC. 5252. The Secretary of War is hereby authorized and directed to have water-gauges established and daily observations made of the rise and fall of the Lower Mississippi River, and its chief tributaries at or in the vicinity of St. Louis, Cairo, Memphis, Helena, Napoleon, Providence, Vicksburg, Red River Landing, Baton Rouge, and Carrollton, on the Mississippi, between the mouth of the Missouri and the Gulf of Mexico; and at or in the vicinity of Fort Leavenworth, on the Missouri; Rock Island, on the Upper Mississippi; Louisville, on the Ohio; Florence, on the Tennessee; Jacksonport, on the White River; Little Rock, on the Arkansas; and Alexandria, on the Red River; and at such other places as the Secretary of War may deem advisable. The expenditure for the same shall be made from the appropriation for the improvement of rivers and harbors, but the annual cost of the observations shall not exceed the sum of $5,000.

The gauges designated in this resolution were established by Major William E. Merrill, Corps of Engineers, the latter part of 1871, except that at Carrollton, established in January, 1872. A gauge was placed at the mouth of the White River instead of Napoleon, as half the latter place had been washed away, including all the old bench-marks, and the mouth of White River was the most desirable location in that vicinity and of greatest convenience to the steam-boat interest. A gauge was established at Natchez, Miss., also, and an additional one at Louisville, gauges being required both at the head and foot of the falls. Observations were commenced at each station as soon as the gauge was established, and with a few exceptions have been continued regularly since.

A gauge at Nashville, Tenn., on the Cumberland River, was established by Major Merrill, in August, 1873.

The gauge at Rock Island, Ill., was discontinued April 30, 1879, for the reason that observations so far north were not needed.

The old gauge at Fort Leavenworth, Kans., was abandoned November 30, 1886, on account of its being out of repair, and the cost of renewal

and inspection too great to be borne by the appropriation. The gauge belonging to the Missouri River Commission was used in its place until September 30, 1889; payment for observations being made by this office, and inspections and repairs by the Commission. On the latter date I was relieved of charge of the gauge, on account of its distance from this station and because the appropriation pertained more particularly to the Lower Mississippi and tributaries, the Commission having expressed the intention of maintaining the observations.

During the fiscal year four new gauges were established, viz: On Red River at Shreveport, La., February 20; Garland, Ark., February 21, and Fulton, Ark., February 22; and on Mississippi River at Donaldsonville, La., June, 9. The gauge at Shreveport is the one set up for the Red River Survey in May, 1889.

In 1881 bulletins were erected at the stations on the Mississippi, for the purpose of giving passing steam-boats the stage of water at each reading. (See description, page 1437, Report Chief of Engineers, 1881.) The wood-work had decayed from exposure during the last nine years, and instead of attempting to repair them, it was decided to construct larger ones for use on the Mississippi and repaint the old plates, build new frames and use them at stations on the tributaries, which, with the exception of Alexandria, have not been provided with bulletins. The last of the large bulletins was completed and set up in June. The plates are made of sheet-iron 48 inches by 40 inches by $\frac{1}{16}$ inch, more than twice the size of the old ones, and the white characters on a black ground are large enough to be distinguished readily with the naked eye at a distance of half a mile.

Since February 1, 1887, the gauges have been read and bulletins changed at 8 a. m. and 4 p. m. daily, to secure greater uniformity and accuracy; formerly they were read at 8 a. m. only.

The engineer gauges are used by the Signal Service at St. Louis, Mo., Cairo, Ill., Memphis, Tenn., Helena, Ark., Vicksburg, Miss., Nashville, Tenn., and Alexandria, La.

The amount expended to June 30, 1889, was $74,233.71. Owing to small and irregular appropriations the records were made continuous with great difficulty until the passage of the river and harbor act of August 11, 1888, which provided a permanent appropriation, as follows:

SEC. 6. That for the purpose of securing the uninterrupted gauging of the waters of the Lower Mississippi River and its tributaries, as provided for in joint resolution of the 21st of February, 1871, upon the application of the Chief of Engineers, the Secretary of War is hereby authorized to draw his warrant or requisition from time to time upon the Secretary of the Treasury for such sums as may be necessary to do such work, not to exceed in the aggregate for each year the amount appropriated in this act for such purpose: *Provided, however,* That an itemized statement of said expenses shall accompany the Annual Report of the Chief of Engineers.

Requests are made from time to time for new gauges and bulletins, by parties interested in navigating tributary streams as well as Mississippi River, and therefore a larger amount should be given to extend this valuable service. On Yazoo River there should be a gauge and bulletin at Greenwood, near the junction of Tallahatchee and Yallabusha rivers, and at least one other at some convenient place below the gauge at Yazoo City, probably near the railroad bridge about 15 miles northward of Vicksburg.

On Ouachita River gauges should be established at Camden, Ouachita City, near the mouth of Bayou Bartholomew, Monroe, Catahoula Shoals, Columbia or Harrisonburgh, mouth of Bœuf River, Trinity, near the mouths of Tensas and Maçon, and Little rivers, and at the junction of Black with Red River.

It would be of great benefit to pilots if, in addition to these gauges, large gauge posts were set up at the principal shoals, to be read by the pilots themselves, and from which they could calculate navigable depths by a table of depths for each gauge.

Special efforts have been made during the past year to find the benches of the Delta Survey, and so connect the observations of early years with those since 1871. This work has been done in co-operation with Captain Powell, secretary of the Mississippi River Commission, and will be continued until the Delta system has been restored or it is found that such connections can not be made. Enough has been learned while investigating this subject to show the absolute necessity of establishing a great number of benches for each gauge, to insure the finding of at least one after a short period of, say, a dozen years, and of describing and sketching the same so that they can be identified. I propose to photograph the gauges and bench-marks hereafter, in addition to descriptions in text and references to map. The importance of referring all gauges to the same datum plane can not be overestimated. On Mississippi, Ouachita, and Red rivers, and at the railroad crossings of all tributaries between Vicksburg and Shreveport, every gauge and known water-mark has been connected with the several datum planes of the Mississippi River surveys: in part by precise levels, and the rest by ordinary and railroad levels which will be checked from time to time, when opportunity offers, and in connection with other work.

The gauges on Arkansas and White rivers will be connected the coming season with the precise levels of the Mississippi River and the U. S. Coast and Geodetic Survey. The gauge at Yazoo City is connected with the Mississippi River by ordinary levels, and if other gauges are established they can be connected in the same way at small expense. The gauges on Cumberland, Tennessee, and Ohio rivers are not connected with any system, there being no continuous survey of these streams, and as such connections would be of value in their improvement the work ought to be shared between the appropriations for them and for maintaining the guages. All of this work can be done at comparatively small expense, and without increasing the amount for gauges unduly.

I recommend, therefore, that the sum of $12,000, or so much thereof as shall be found necessary, be appropriated in the same terms as expressed in section 6 of the act of August 11, 1888, making the gauge service continuous, to provide for maintaining the present gauges and increasing the service as suggested.

The amount allotted for gaugings at or near St. Paul, Minn., for the past fiscal year was $600, leaving $9,000 available for the gauges under my charge. Observations were continued at all the permanent stations, and in February temporary gauges were set up at the sites of the Delta Survey gauges at Memphis, Tenn., Natchez, Miss., and Baton Rouge, La., which were read simultaneously with the regular gauges during the flood and until the end of June, in order to obtain, if possible, connections with the old gauges of the Mississippi Delta Survey. Both gauges at Vicksburg were read simultaneously since February 10, to determine the difference in slope between the elevator and Kleinston during high stages.

Reports are received at this office weekly, and, after review, are consolidated and sent to the secretary of the Mississippi River Commission for revision, and have been published by him to the end of the calendar year 1889.

Records of the daily readings were furnished the president of the

Mississippi River Commission since February. Copy of the Florence record was furnished Lieutenant-Colonel Barlow; copy of the Carrollton record was sent the assistant engineer at South Pass of the Mississippi River; and copies of the records of various stations below Memphis were furnished district officers and levee commissioners during the flood this spring and summer.

The following gauges were inspected and repaired by Assistant Engineer John Ewens during the fiscal year ending June 30, 1890:

July.—(2d) Red River Landing, La., an extra section reading from 23 to 32 feet put in; (4th) Baton Rouge, La.; (6th) Carrollton, La.; (27th) Natchez, Miss., gauge rebuilt from 20-foot mark (the lowest point stage of water would permit) to 50-foot mark; (31st) Vicksburg, Miss., gauge rebuilt from 20 to 50.4 foot mark, and bulletin repaired and painted and moved to better location.

August.—(5th) Lake Providence, La., gauge rebuilt from 17 to 34 foot mark; (7th) Mouth of White River, Ark., guage rebuilt from 17 to 50 foot mark; (12th) Jacksonport, Ark., gauge rebuilt from 23.1 to 32.83 foot mark; (13th) Little Rock, Ark., an entire new gauge built from —1 to 34 foot mark; (14th) Helena, Ark., an entire new gauge built from 0 to 51-foot mark; (16th) Memphis, Tenn., gauge rebuilt from 0 to 38 foot mark; (18th) Florence, Ala., an entire new gauge built from 0 to 34 foot mark; (20th) Nashville, Tenn., gauge rebuilt from 29 to 35 foot mark and from 46 to 53 foot mark; (21st) Louisville, Ky., gauge cleaned of slime and repainted; (23d) St. Louis, Mo.

September.—(1st) Cairo, Ill.; (3d) Helena, Ark.; (6th–9th) Vicksburg, Miss., gauge at Kleinston rebuilt from —4 to 52 foot mark, and large new bulletin erected; (13th) Red River Landing, La., gauge rebuilt from 0 to 17 foot mark.

October.—(1st) Red River Landing, La., a new section from 0 to 10-foot mark put in.

January.—(31st) Red River Landing, La., gauge rebuilt from 28 to 50 foot mark.

February.—(6th) Baton Rouge, La., gauge rebuilt from 27 to 38 foot; (7th) Carrollton, La., gauge rebuilt from 7 to 15 foot mark; (10th) Vicksburg, Miss.; (11th) Lake Providence, La., gauge extended and duplicated from 27.5 to 45 foot mark, to prevent possibility of error at flood stages; (15th) Natchez, Miss.; (18th) Alexandria, La.; (20th) Shreveport, La., gauge established; (21st) Garland, Ark., gauge established; (22d) Fulton, Ark., gauge established.

April.—(4th) Little Rock, Ark.; (5th) Jacksonport, Ark., gauge rebuilt from 29 to 36 foot mark, and high-water mark (March 14, 1890) leveled to and found to be 33,347 feet; (8th) St. Louis, Mo., inclined gauge found to be disturbed by settling and continuous heavy traffic over it; true elevation of all marks above water-surface obtained, so that corrections could be applied to readings; (14th) Cairo, Ill., inclined gauge disturbed by same causes as at St. Louis, and all marks leveled to as at that place; (17th) Memphis, Tenn., new bulletin erected in custom-house yard, and temporary gauge at site of Mississippi Delta Survey gauge connected with permanent gauge; (19th) Florence, Ala.; (21st) Nashville, Tenn., inclined gauge disturbed by same causes as at St. Louis, and all marks above water leveled to; (23d) Louisville, Ky., both gauges; (26th) Helena, Ark.

May.—(3d) Baton Rouge, La.; (7th) Carrollton, La.; (15th) Natchez, Miss. The bench-marks of the Mississippi Delta Survey were connected with the gauges at Plaquemine and Donaldsonville, La.

June.—(9th) Donaldsonville, La., gauge established; (11th) Baton Rouge, La., bulletin erected; (13th) Natchez, Miss., bulletin erected.

The frequent and rigid inspections of the gauge stations by Assistant Engineer John Ewens have improved the service in a marked degree. Observations are taken with more care, interpolations are less frequent, and the records kept better than ever before. These are indicated in the hydrographs issued by the secretary of the Commission. It is proper to note here, in reference to the assertion that the zeros of some of the gauges have been tampered with, that in every case where it has been found necessary to make a change in the position of the zero of a gauge a careful record has been made of the amount of the change and levels run from the new gauge to the old bench-marks. When the gauges were re-established in 1871 it was the intention of the officer in charge to put the Mississippi gauges as near as possible in the places occupied by the Delta gauges, and at the same elevations, taking all precautions, however, to put the zeros at or below the lowest water known; and for the latter he had to depend upon tradition or vaguely remembered water marks. For example, the Natchez gauge was set too high and was lowered 1.2 feet, and it is still higher than the Delta gauge, but the amount has not yet been finally determined. The Vicksburg gauge was set too high by something less than 2 feet as compared with the Delta gauge, and as low water of 1887 was 3.91 feet below the zero, it is still nearly 4 feet too high. The Cairo gauge is thought to be nearly correct in elevation, but there is an apparent difference of 1.4 feet between it and the Delta gauge, due, it is believed, to an error of about that amount in the levels run in December, 1857, from the Cairo company's bench to the water-surface. The charge that the engineers had changed the zeros of the gauges because the bottom of Mississippi River was rising is therefore disproved by the record. If there is anything in these differences of readings except abnormal oscillations the inference should be that the low-water lines are falling, and therefore that the depths of the river are generally increasing.

Comparison of flood of 1890 with highest water previously recorded.

Gauge stations.	Elevation of gauge zero above Cairo datum plane	Highest water previously recorded.		Highest water of 1890 to June 30.		Relation to previous highest record.	
		Year.	Gauge-reading.	Date.	Gauge-reading.	Above.	Below.
	Feet.		*Feet.*		*Feet.*	*Feet.*	*Feet.*
St. Louis, Mo.	400.23	1844	41.39	Apr. 29	18.97	.....	22.42
Cairo, Ill	290.84	1883	52.17	Mar. 12	48.83	.....	3.34
Memphis, Tenn	203.97	1887	35.30	Mar. 23, 24; Apr. 4, 5	35.60	0.30	.....
Helena, Ark	161.98	1886	48.10	Mar. 29, 30	47.72	.....	0.38
Mouth White River, Ark	128.73	1882	48.40	Mar. 31	50.40	2.00	.....
Lake Providence, La.	89.62	1862	40.87	Mar. 15	41.05	0.18	.....
Vicksburg, Miss.	66.04	1862	51.10	Apr. 24, 25	49.05	.....	2.05
Natchez, Miss	36.89	1862	50.30	Apr. 23	48.54	.....	1.76
Red River Landing, La.	23.85	1882	48.50	Apr. 23	48.77	0.27	.....
Baton Rouge, La.	20.06	1884	36.20	Apr. 21, 22	36.58	0.38	.....
Donaldsonville, La.	20.72	1884	29.45	Apr. 23	28.00	.....	1.45
Carrollton, La.	20.91	1862	15.90	Mar. 13, 17	16.13	0.23	.....
Louisville, Ky (upper)	.....	1884	46.60	Mar. 28	35.40	.....	11.20
Louisville, Ky (lower)	.....	1884	72.00	Mar. 28	61.20	.....	10.80
Florence, Ala.	.....	1867	31.08	Feb. 28	23.40	.....	7.68
Nashville, Tenn	.....	1882	55.10	Mar. 6	50.70	.....	4.40
Jacksonport, Ark	.....	1867	32.83	Mar. 14	33.35	0.52	.....
Little Rock, Ark	.....	1857	31.00	Apr. 29	26.80	.....	4.20
Alexandria, La.	64.46	1866	36.46	May 19	36.85	0.39	.....
Shreveport, La.	161.27	(*)	(*)	May 8	34.70	.....	.....
Garland, Ark.	.....	(*)	(*)	Apr. 30	28.17	.....	.....
Fulton, Ark.	.....	(*)	(*)	May 3	31.00	.....	.....

* Not determined on present gauges.

Cairo datum is a plane 300 feet below the reading 9.16 feet on the Cairo gauge. The preliminary elevation of mean Gulf level at Biloxi, Miss., reported by the Mississippi River Commission is 21.26, but as this has not been adopted finally references to mean Gulf level will not be made until an agreement is had between the Commission and the Coast Survey, the latter now being engaged upon an interior secondary line of precision from Biloxi to Cairo.

By deducting 21.26 from the elevations given above the approximate elevations of the gauge zeros with reference to mean tide at Biloxi may be determined.

As some doubts exist about flood heights reported at a few places previous to the re-establishment of the gauges in 1871, especially during the rebellion, and as some of the gauge benches of the Delta survey have not been fully identified, a careful study of the subject is proposed in company with the secretary of the Commission during the next fiscal year. Zeros will be reconnected with the precise system where possible, and reduced to the Cairo datum. Where low water has fallen below zero, gauges will be set down enough to prevent confusion from minus readings, and all changes will be noted in the next report.

ITEMIZED STATEMENT OF EXPENSES OF FISCAL YEAR ENDING JUNE 30, 1890, SUBMITTED IN COMPLIANCE WITH REQUIREEENT OF SECTION 6 OF THE RIVER AND HARBOR ACT OF 1888.

Observations:		
Pay of 17 permanent gauge-keepers for year	$3,093.00	
Pay of 3 permanent gauge-keepers on Red River and 1 on the Mississippi at Donaldsonville, La., since establishment of additional gauges	143.33	
Pay of gauge-keeper at Fort Leavenworth, to Sept. 30	30.00	
Pay of 4 temporary gauge-keepers at Memphis, Vicksburg, Natchez, and Baton Rouge, dur.ng floods	333.00	
Extra pay allowed Vicksburg gauge-keeper during flood, on account of expenses for skiff hire, etc	29.50	
		$3,628.83
Inspections and repairs:		
Pay of gauge-inspector, 5⅓ months, at $150	770.00	
Traveling expenses of gauge-inspector	539.75	
Pay-rolls of employés hired by inspector, rod-men, skiff-men carpenters, laborers, etc	107.80	
Pay-rolls of employés establishing and connecting with bench-marks at Vicksburg and Meridian, Miss., Shreveport, La., etc	163.17	
Traveling expenses of employés on above service	46.33	
Transportation of instruments	7.95	
New bulletins and repairs of old bulletins	1,532.52	
Hauling and erecting bulletins	34.00	
Material for repairs of gauges	215.14	
Transportation of material	17.30	
		3,433.96
Office expenses and incidentals:		
Office pay-rolls	467.00	
Stationery	13.25	
Telegrams	5.19	
Rent of post office box	2.25	
Transportation of note-books from Washington	1.70	
Rubber stamps for marking gauges	2.85	
One new engineers' level for gauge-inspector	146.00	
Traveling-cases for level, rod, and tripod	19.00	
Spirit-level	3.50	
		660.74
Total		7,723.53

Money statement.

July 1, 1889, amount available (provided by act of August 11, 1888)		$9,600.00
July 1, 1890, amount expended during fiscal year	$7,178.34	
July 1, 1890, amount allotted for gaugings at St. Paul	600.00	
July 1, 1890, outstanding liabilities	5.19	
		8,323.53
July 1, 1890, balance unexpended		1,276.47
Amount that can be expended profitably in fiscal year ending June 30, 1892. Submitted in compliance with requirements of sections 2 of river and harbor acts of 1866 and 1867.		12,000.00

W 18.

SPECIAL REPORT ON IMPROVEMENT OF CYPRESS BAYOU AND THE LAKES BETWEEN JEFFERSON, TEXAS, AND SHREVEPORT, LOUISIANA.

UNITED STATES ENGINEER OFFICE,
Vicksburg, Miss., February 26, 1890.

GENERAL: In compliance with your instructions, I have the honor to report upon the improvement of Cypress Bayou and the lakes between Jefferson, Tex., and Shreveport, La., as called for in the following House resolution received from your office February 11, 1890:

[Fifty-first Congress, first session, Congress of the United States.]

IN THE HOUSE OF REPRESENTATIVES,
February 6, 1890.

Resolved, That the Secretary of War is hereby requested to furnish to the House of Representatives, at as early a day as may be practicable, all information that may be obtained in his Department in relation to the improvement of Cypress Bayou and the lakes between Jefferson, Tex., and Shreveport, in the State of Louisiana; and that he make such suggestions as he may see proper for the improvement of such bayou and lakes, and the amount necessary to accomplish the same.

Attest:

EDWD. MCPHERSON,
Clerk.

All the information upon this subject available in this office is contained in the reports of the Chief of Engineers since 1870, a few sketches of the bayou and lake region, and House Document No. 103, Forty-eighth Congress, second session.

I have gone over the reports very carefully, and give the essential portions and recommendations in a connected form as being the best means of presenting the information required. Should it be desired to

refer to the reports themselves, the following index to the reports of the Chief Engineers, year and pages, will be found convenient. The reports will be found under the head of Cypress Bayou and also of Red River, removing raft, etc., and contain sub-reports of assistants, commercial statistics, and letters upon the subject: 1870, 62; 1871, 66; 1872, 568; 1873, 620, 668; 1874, 706, 720; 1875, 528; 1876, 597; 1877, 488; 1878, 633; 1879, 957; 1880, 1280; 1881, 1428; 1882, 1561; 1883, 1161; 1884, 1332; 1885, 1493, 1552; 1886, 1347; 1887, 1453, 1490, 1494; 1888, 1343; 1889, 1589, 1595.

The first recommendation for improving Cypress Bayou was made by Lieutenant Woodruff in 1872 in a report to Captain Howell, engineer in charge. He submitted an estimate of $20,000 for opening a route through the bayou from Bois d' Arc Pass into the lake, and of $12,000 for dredging. He also recommended an expenditure of $70,000 for a dam at the foot of Sodo Lake to contract the water-way at low stages if it should be decided to remove the Red River Raft.

Captain Howell considered the information too meager for discussion, but recommended the estimates as being the "best approximates" that could be made at the time. He was fully justified in this because there was an urgent call for the removal of the raft for the immediate benefit of navigation above and below Shreveport, and for the relief of the people of that region from the danger of overflow. (1872, 568.)

The following year Captain Howell devoted the appropriations of 1872-'73, amounting to $60,000, to continuing the work of dredging, begun by the city of Jefferson, in accordance with a project approved in May, 1873. In his report for that year he said (1873, 623-671):

> I have grave doubts as to the value of a lock and dam at Albany Point. Lieutenant Woodruff will examine the matter more clearly and report upon it this winter.
>
> In the meantime the money appropriated can be advantageously used as proposed in Cypress Bayou and on Albany Flats.
>
> The work is of benefit to commerce, since for a portion of the year it will provide improved water communication between Jefferson and the Gulf of Mexico. I do not think that the results of the work can be considered as permanent because of the well-known tendency of streams flowing through an alluvial formation to make their own beds to suit the fixed laws assigned them by nature, unless hemmed in by art, and to form bars wherever nature allows them to expand laterally. Dredging only temporarily counteracts this tendency.
>
> Excavation in a rocky bed by diminishing the width of the stream may make permanent increase of channel depth; but increase of depth in an alluvial stream, or on an alluvial bar, unless measures are taken to decrease the width of water-way, can only last for a few years or months; water in such case will work at the expense of the banks rather than of the bed of the stream.

Lieutenant Woodruff's report for the same year was forwarded without discussion, Captain Howell stating that he was not prepared to indorse a plan for lock and dam navigation between Jefferson and Shreveport, but directed further investigation of the project. A more extended survey was made the next season, and upon the review of the information then and previously collected Captain Howell submitted a "definite plan for the improvement desired."

The following special report was sent to the Chief of Engineers May 1, 1874, in response to a request from the chairman of the Committee on Rivers and Harbors for immediate report, before he was able to complete the chart of the last survey:

> Plans for improvement have been matured, and that considered best, with estimates is submitted without discussion, which must be reserved for a later report, accompanied by charts.
>
> For the location of Leavenworth's section reference is made to the chart which accompanied Woodruff's report on survey of Red River Raft region and Cypress Bayou.
>
> Cypress Bayou was evidently an unnavigable stream until after the advance of the

Red River raft, above Shreveport, converted its bottom lands into what are now known as Cross Lake, Sodo Lake, and Fairy Lake.

The removal of the raft, though too recent to have yet had well-observed effect on the level of these lakes, it is thought, will reduce this level and shorten the period of navigation between Shreveport and Jefferson.

To prevent this reduction, and at the same time raise the low-water level along the west bank of the route, it is recommended to construct a dam from Albany Point across to Red River on a line following near Leavenworth's section, and at the same time excavate above it a navigable cut connecting Sodo Lake with Red River.

The dam crossing the foot of Sodo Lake to be built 2 feet above the high-water mark of 1866, at Albany Point, which is 43.16 feet above the zero of the United States gauge at Shreveport, until entering the dense cypress brake opposite Albany Point, then to be depressed 9 feet, and at that level carried until it reaches the bank of Red River.

As shown by our levels, this will raise the extreme low water in Sodo Lake at the dam about 4 feet, and at Jefferson 1 foot, giving navigation at all seasons, from Shreveport to Jefferson for vessels drawing 5 feet and less, whereas heretofore at extreme low water there has been but 10 inches available.

The depression in the dam will allow the water, after raising 9 feet at the dam and 6 feet at Jefferson, to waste over its top, through the cypress brake, into Cross Lake.

Until the water has raised to the top of this portion of the dam it will discharge through the cut into Red River, and, it is thought, materially improve that portion of the river below it, without injury to the plantations on its banks.

The rise in Sodo and Fairy Lakes can do no harm, for it will only permanently overflow what is already swamp land. The waste over the dam and backwater from Shreveport will keep Cross Lake filled.

The work is estimated to cost $300,000, and must be begun and completed during a single low-water season.

No appropriation of less than $300,000 is therefore desirable. The last appropriation made by Congress for dams and dredging in Cypress Bayou and at foot of Sodo Lake has been partially expended and can be wholly expended to advantage in dredging and clearing the channel above the proposed dam.

The following is taken from Captain Howell's report upon the project, sub-reports, details, &c., being omitted (1874, 706–720):

I. Improvement of Cypress Bayou.

Cypress Bayou proper is a small stream passing Jefferson, Tex., and debouching into the head of Fairy Lake, and is thence connected with Red River by a chain of lakes, generally known as the Sodo Lakes.

The work of improvement during the past year has been confined to the bayou. It has consisted in dredging bars, widening and straightening the low-water bed of the stream, removing snags, logs, and stumps from the bed, and protruding logs and overhanging trees from the banks.

* * * * * * *

II. Construction of Dams and Dredging at Foot of Sodo Lake.

In his report of April 29, 1872, which was a preliminary report on a survey of Cypress Bayou, and made before the operations of the survey were fully completed, Lieutenant Woodruff recommended the construction of certain dams at the foot of Sodo Lake, to confine the low-water discharge at that point to a single narrow channel or chute. The appropriation of March 3, it is believed, was based on this recommendation.

In his final report on the survey (1873, 669) Lieutenant Woodruff states that the supposition on which he based his first recommendation he afterward found to be entirely incorrect, and recommends the substitution of a lock and dam for the dams previously projected. In submitting this report to the Chief of Engineers, I stated that I was not prepared to indorse the plan and had directed further investigation. This investigation Lieutenant Woodruff was directed to make during the season of extreme low water in the fall of 1873. Preparations for the work had been made, and it is presumed that the visit to Shreveport, resulting in his death, was made by Lieutenant Woodruff with the intention of proceeding with the examination. Finding himself in the midst of an epidemic, unable to get assistance, having been exposed to disease, and unwilling to risk carrying that disease among his employés at work on Red River raft, he did what was proper, prudent, and humane, though his action cost him his life. His death suspended the investigation directed, and it was late in December, 1873, before a party could be placed in the field to make it.

In December, Mr. H. A. Leavitt, assistant engineer, was employed to make the sur-

vey, the field work of which was completed March 10, 1874. The work was plotted, and Mr. Leavitt's report, with plans and estimates, available at the close of May. It was then too late in the season to commence work on the plan suggested, even had the amount of appropriation available warranted.

Pending investigation and survey above reported, it was proposed, in place of dredging at the foot of Sodo Lake, to remove stumps and logs from the channel through the foot of the lake, and Lieutenant Woodruff was instructed to avail himself of the first favorable stage of water for doing this work. For the reason stated above the favorable season of 1873 was lost and the project abandoned for the year.

With the light we now have it must appear well that money has not been expended on either of the three projects named above.

It is now possible for me to submit a definite plan for the improvement desired, and in doing so I will first present a description of the navigation from Jefferson to Shreveport, and afterward a discussion of the several plans for improvement that have been considered.

DESCRIPTION.

Jefferson, Tex., is at the head of navigation in Cypress Bayou. From that point down to the head of Fairy Lake, a distance of 27 miles, the Bayou at low water is narrow, tortuous, and before improved was shallow and greatly obstructed by timber. Fairy Lake, from its head for about half its length, is thickly studded with cypress trees, stumps, and fallen timber, through which the old channel of Cypress Bayou may yet be traced at low water, and this, if cleared of logs and stumps, would afford low-water navigation of about 2 feet.

In high water this channel is partly followed by steam-boats, and partly avoided by use of what are known as "cut roads." The lower half of the lake affords a navigation of over 6 feet.

At its foot the lake enters the valley of Red River between bluffs, but 1,480 yards apart. At this point it meets the whole discharge from Red River that is made by the latter through breaks in its western bank between Hurricane Bluff (directly opposite the foot of the lake) and Blanton's Landing, 22 miles above.

January 1, 1872, when at Albany Point the water surface was 6 feet above extreme low water, the surface of this point was found 2.3 feet below the surface of Jefferson (25 miles distant in a straight line), 38 feet below the surface of Red River at Blanton's Landing (22 miles distant), and 11 feet below that at the nearest point on Red River (5 miles distant).

The great body of water concentrated at this point finds vent through Willow Pass into Sodo Lake, giving the pass a depth of from 20 to 30 feet, but at its foot, where the water spreads into Sodo Lake, forming a bar having over it only a depth of about 2 feet at low water. Through the lake there is a depth of from 3 to 5 feet, and at its foot a wide shoal, known as Albany Flats, with a depth of but 1 foot at extreme low water.

This lake forms a settling basin for the Red River water drawn through it. The slope of its water surface at the date before stated was but 1½ inches to the mile. It is gradually filling up with Red River deposit.

Below Albany Point the old channel of Cypress Bayou is well defined, and affords good low-water navigation through the upper portion of Cross Lake, Twelve-mile Bayou, and Red River, at Shreveport.

At Albany Point, January 1, 1872, the surface of the water was 6.3 feet below the surface in Red River at the nearest point, 2.3 miles distant. At the head of Twelve-mile Bayou the water surface was 2.8 feet below Red River opposite, a distance of 704 yards.

The fall from Albany Point to Shreveport was 11.8 feet; from Red River, opposite Albany Point, to Shreveport, 18.1 feet.

From this it appears that the foot of Fairy Lake is the center of a basin, having Red River on one side and the line of bluffs to the west of it on the other.

The raft in Red River, along the eastern rim of this basin, deflected the greater portion of the river-discharge above the raft into the basin, thus converting what before the advent of the raft was a cypress swamp, with a sluggish, unnavigable stream flowing through it, into a series of lakes, affording good navigation for the greater portion of each year.

It is feared on the part of the commerce interested that the removal of the raft will immediately effect a shortening of the season for this navigation, and perhaps ultimately return it to its original condition.

It is too early to determine if such fear be well grounded.

It is desirable at present to obtain a three-foot low-water navigation from Shreveport to Jefferson; this is probably as much as will ever be required. To obtain this the following plans have been considered:

(1) Dredging.

(2) Wing-dams at Albany Point.

(3) A lock and dam at Albany Point.
(4) A tumbling or other dam at Albany Point, with a cut into Red River.
(5) A dam across Willow Pass, at the foot of Shift-tail Lake, and the re-opening of Irishman's Bayou.
(6) A dam in Cross Lake and Twelve-mile Bayou, with a cut from near the head of this bayou to Red River.
The following consideration of these several plans is submitted:

DREDGING.

Beginning at Albany Point, on a straight line through Sodo Lake, the distance to deep water in Willow Pass is about 8 miles; over this line the depth at low water varies from 1 to 5 feet. This is the line that apparently should be adopted for a dredged channel through the lake, for the reason that, except through a very short portion of the lake (about one-quarter its length), the old channel of Cypress Bayou has been obliterated by deposit, while that portion that may yet be traced is so narrow and tortuous that it would require widening and straightening by dredging to put it in good condition.

Dredging on the straight line indicated, to obtain a 3-foot channel, would require excavation to a depth of about 2 feet for 1 mile over Albany Flats, and excavation of about 1 foot, for the same distance, at the foot of Willow Pass, a total excavation of about 35,200 cubic yards for a channel 60 feet wide.

The excavation would run through the remains of a cypress swamp, and would consequently be very expensive. Further, it has been shown by the surveys made that Sodo Lake is the main settling basin for the Red River water passing through it.

The deposit in this lake has been so great as to entirely cover the knees of the cypress yet standing in the lake, while in the other lakes these knees are yet uncovered.

The depth of such deposit was not ascertained, nor is it known for how long a time it has been forming, but the covering of cypress knees indicates a thickness of several feet, and the living trees at points in the lake show it to be a very recent formation. The inference is that since the cause of deposit does and will continue, any dredged channel through the lake must sooner or later be silted up. If, then, dredging be resorted to, the depth should be made considerably greater than actually necessary for the time being, in order to avoid annual dredging to keep the channel open.

I assume, therefore, that the depth of a dredged channel through Sodo Lake should be 6 feet at extreme low water. This would make an average dredging of about 2 feet 60 feet wide for a distance of 8 miles, equal 563,200 cubic yards of excavation. This of itself appears sufficient to condemn dredging, but when there is added to it the dredging that would have to be done in the upper end of Fairy Lake and across bar at the present mouth of Cypress Bayou it is clear some other plan of improvement should be considered.

WING-DAMS AT ALBANY POINT.

This was Woodruff's first recommendation. He afterward found that the chutes he proposed to close with dams were so nearly dry at low water that but little, if any, concentration of low-water discharge would be effected by the dams, and that consequently they would be of little or no use in holding the last stages of a flood in Sodo Lake to prolong navigation through it.

LOCK AND DAM AT ALBANY POINT.

This was recommended by Lieutenant Woodruff in his final report of survey of Cypress Bayou, and the plan was well calculated to give at all seasons a depth of 6 feet from Albany Point to Jefferson. Having doubts of its low-water effects below Albany Point, I have awaited the results of the further survey ordered before considering the project.

The survey of Mr. Leavitt, besides disclosing difficulties of foundation not anticipated by Lieutenant Woodruff, shows that without the interposition of a second lock and dam between the first and Shreveport in low water the bayou and lake below Albany Point for a distance of nearly 6 miles would run dry.

The first lock would require a lift of 10 feet, the second a lift of 13 feet, at low water of 1873 at Shreveport, to make a 3-foot low-water navigation from that point to Jefferson.

The walls and gates of the locks would have to be 26 feet high in order not to be overtopped at a stage of water equal to the high water of 1866, the highest of which we have record.

In view of the above the project was rejected, and it was not considered necessary to make detailed plans and estimates for it.

DAM AT ALBANY POINT AND CUT INTO RED RIVER OPPOSITE.

Woodruff's survey showed the whole fall from Jefferson to Albany Point to be but 3.5 feet at a time when there was 4-foot navigation over Albany Flats. Of this fall, 2.3 feet was from Jefferson to the head of Fairy Lake. The lake was a level; from the foot of the lake to Albany Point the fall was 1.2 feet.

By placing directly across the water-way at Albany Point a dam having its crest 14 feet below the local high-water mark of 1866, there will be given over Albany Flats a depth of about 6.5 feet, whence from the above it is evident there will be given to the foot of Fairy Lake a least depth of 5.3 feet, and from thence to Jefferson a least depth of 3 feet throughout the year.

It is considered that the latter depths will be greater than stated, for the reason that the slopes reported will not probably be very greatly diminished; also, no allowance is made for the dredging from Jefferson to the head of Fairy Lake, a distance in which the greater fall occurs, for the reason that it is anticipated that the dredged places will fill in a few years.

For perfect safety the figures are based on a level from Albany Point to Jefferson.

As such dam while answering the purpose of giving good navigation above it to Jefferson would effectually cut off the navigation below from that above, it would be worse than useless, except a new connection be made with Red River. A cut to Red River from a point above the dam is therefore necessary as a portion of the project.

The difference in level of water-surface between Sodo Lake at Albany Point and of Red River (opposite) at Gold Point renders such connection practicable without lowering the surface created by the dam, as shown by the following:

Our surveys indicate the fact that during all seasons of the year the surface of the lake at Albany Point is lower than the surface of the river opposite at Gold Point, viz: at high water of 1866, when there was between 19 and 20 feet over Albany Flats, the lake surface was 2.38 feet below that of the river.

In 1872, with 4 feet over the flats, it was 6.3 feet below; and in 1867, with between 2 and 2½ feet over the flats, it was 3.8 feet below.

Although no observation was made to determine the difference of level at extreme low water, viz., when there is but 1 foot of water over the flats, it is assumed that this difference is probably not less than 2 feet, inasmuch as the measurements given were all made before the removal of the raft.

Under this assumption the proposed dam and cut should give at all seasons of the year 3 feet navigation over Albany Flats, a sufficient depth for the present, since the river below Shreveport only affords a depth of 20 inches during low water; and it is not the local trade between Shreveport and Jefferson that is to be served by improvement, but the trade between the Mississippi River and Jefferson.

Besides the improved navigation it is designed to give above Shreveport, this project presents another subject for consideration.

It is claimed that in case the removal of the raft should prove to effect a shortening of navigation through the Sodo Lakes, it will also shorten the season below Shreveport.

This is on the supposition that the lakes serve as reservoirs to detain floods of Upper Red River, so that they are longer in passing Shreveport than they would be if these reservoirs did not exist. If this be true, then the reservoirs are useful in lengthening the season of navigation below them.

The plan of a dam and cut at Albany Point appears to present the means not only for preventing any possible deterioration of these lakes as reservoirs, but also a probable means for increasing their efficiency.

In connection with this three plans for a dam have been considered, and these require notice.

First. A tumbling dam having its crest 14 feet below the local high-water mark of 1866. This is the one so far assumed for illustration and the one called for if navigation above it is alone to be considered.

In this case there is but one objection to it, and that may be overcome by a suitable construction. The objection is this: The character of the foundation offered for a tumbling dam is not favorable to permanence of the structure, the soil being of an easily abraded mixture of sand and clay, with strata of sand at intervals. During low water the bed of the lake at the foot of the dam will be dry, while just above on Albany Flats, there will be from 3 to 6 feet.

At the commencement of a rise, when the water begins to flow over the dam, the fall over the several portions of the length of the dam will range from zero to 15 feet. It will afterward be some time before the lake below fills sufficiently to afford a useful water-cushion to break this fall. At extreme high water the surface of the upper lake will be from 10 to 14 feet above the crest of the dam, and the lake below will probably be filled to nearly the same level; during the intermediate stages we must expect powerful eddies about the foot of the dam.

These facts suggest difficulties of construction which may certainly be overcome, but at great expense, and by taking every precaution to have workmen and material on hand so as to begin and complete the work in a single low-water season, the length of which may only be safely assumed at four months, and those four months the most unhealthy of the year.

If we further look to this dam as a means for increasing the efficiency of the Sodo Lakes as reservoirs, then it must appear too low to have any appreciable effect, for it has been shown that during all, except the lower stages, water must run from Red River to the lake rather than from the lake to the river, while after the lake has fallen to the crest of the dam, and further discharge must be into the river, the possible fall of 3 feet, taken in connection with the area of the lake, indicates such a small volume of discharge that it does not need figures to prove it of no value below Shreveport.

Second. A dam from Albany Point to the bank of Red River, having its crest 2 feet above the high water of 1866 on Red River.

As the first plan of dam is the minimum allowable for improved navigation, so this plan appears to offer a maximum for reservoir effect.

It would throw the whole of the lake discharge into Red River through a channel which (following its meanderings) would be 7.6 miles longer between Albany Point and Shreveport than the present route via Twelve-mile Bayou, and 9.1 miles longer than the route via Cross Bayou.

This difference in length would necessarily retard the emptying of the reservoir, but on the other hand we should lose an important portion of the present effect of Lower Cross Lake. The latter would then be only a reservoir in proportion as the water was ponded back into it from Shreveport, whereas now it holds a large volume of the flood-waters received through the Sodo Lakes, for a time after the latter have well run out. This is evidenced by Leavitt's survey and a section displayed on his chart, where it it shown that the water-surface in the neck between Upper and Lower Cross Lake was 3 feet above the surface in Twelve-mile Bayou, 540 feet distant, and the same above Red River, just above.

It is questionable if the gain on the one hand would not be balanced by the loss on the other.

There is another and more serious objection to the plan, viz: The river between the dam and Shreveport has not the capacity to carry the volume to be added from the lakes, and to give it the capacity would require radical changes in its bed, involving the destruction of many plantations.

These two considerations condemn the plan of a high dam.

Third. A dam across the foot of Sodo Lake, having its crest of the height of No. 2; the crest between the lake and river to be depressed to 9 feet below the high water of 1866.

This is a compromise between the first and second, and, while offering the advantages possessed by both, permits the filling of Cross Lake by direct overflow, and, it is thought, will not seriously affect the plantations along the river bank.

This is the plan recommended in my communication of May 1, 1874, transmitted to the Chief of Engineers in answer to the inquiries of the chairman of subcommittee of House of Representatives on Rivers and Harbors.

It is the plan I recommended for adoption on two conditions, viz:

(1) That the money required to carry it out be all appropriated before the work is commenced.

(2) That the commerce to be benefited be found to warrant the expenditure. Of this I do not pretend to judge.

The other two plans considered call for but brief mention.

Fifth. The fall from Red River, through Irishman's Bayou, to the foot of Fairy Lake, January 1, 1872, was 11 feet. It is evident that a dam crossing the head of Sodo Lake, Willow Pass, passing around the foot of Shift-tail Lake, and connecting with the bank of Irishman's Bayou, might be constructed the same as at Albany Point, and to answer the same purposes.

The length of the dam, as indicated on Woodruff's chart, and its great height, due to the depth of Willow Pass, together with the labor of re-opening Irishman's Bayou, which is filled with raft, shoal, narrow and tortuous, condemns the project; further by cutting off the settling basin afforded by Sodo Lake, a great deposit would be induced above the dam, making in a short time, it is anticipated, a second Albany Flats.

Sixth. Mr. Leavitt suggested a dam across the neck between Upper and Lower Cross Lakes, thence across Twelve-mile Bayou to the bank of Red River, and a cut from the bayou above into the river. This was rejected because of the dimensions of the dam required and the insufficient fall from the river to the bayou, the latter being so slight that it could not have effected the depth over Albany Flats.

The location at Albany Point appears to be a proper mean between the two locations last named.

CONSTRUCTION OF DAM MATERIAL.

The neighboring country affords an abundance of cypress timber, which may be delivered in rafts at the site of the work during high water. Albany Bluff affords a good clayey soil. Albany and the neighboring bluffs will furnish, it is thought, enough stone (of a quality not suitable for masonry), that will answer for ballast. No other material for construction can be had except from a great distance and at great expense.

The dam must therefore be mainly built of timber.

A pile-dam, judging from the fate of that built across Tone's Bayou, would probably not stand long.

A framed dam would be difficult of construction, costly, and offer no better hope of permanency than one made by piling.

In the Red River raft we found numerous large islands (comparatively speaking), formed by an accumulation of timber, cemented together by river deposit and the roots of willows; these were able to withstand the full force of the river current during the floods, and were difficult of removal by machinery, even when aided by nitroglycerine.

It is proposed to imitate this natural formation by building a dam with untrimmed cypress trees, placed butts down stream, layer over layer, with the interstices filled in with earth from the bluff, and the top and apron ballasted with stone.

On this plan the cost of a tumbling-dam, No. 1, is estimated at $57,661.

The cost of dam No. 3 is estimated at $217,314.

The cost of the cut is estimated at $154,166.

Total cost of dam No. 1 and cut, $211,827.

Total cost of dam No. 3 and cut, $372,580.

The estimate for the dam is based on the assumption that all materrial for it is to be collected, so that the dam may be constructed during a single low-water season.

The estimate for the cut is based on a width of 60 feet at top, 30 feet at bottom, and a uniform depth of 6 feet below low-water mark.

It is thought that perhaps a cut of lesser dimensions may answer, on the supposition that the currents through it may scour it wider and deeper. This consideration, however, could not be made to safely enter the estimate.

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No estimate has yet been submitted for the cost of completing the work of improvement in Cypress Bayou proper.

My present estimate for cost of work at Albany Point is made greater than that submitted in my letter of May 1, 1874, by the addition of ballast in the construction of a dam, an addition which, if not positively necessary, is certainly prudent.

I am unable to state if it may effect permanent improvement or not.

No money having been appropriated for the work since March, 1873, and no action having been taken upon the project, so far as I can learn, Captain Benyaurd, who succeeded Captain Howell in November, 1874, submitted the question in his report for the next fiscal year whether or not Captain Howell's plan should be carried out. He made no estimates either for removing obstructions or for the dams, evidently considering the subject exhausted until Congress should decide. The following is from his report (1875, 529).

CONSTRUCTION OF DAMS AND DREDGING AT THE FOOT OF SODO LAKE.

No work was done toward carrying on the work above indicated. The amount of the appropriation available was insufficient to attempt anything in that direction, and it was accordingly expended upon Cypress Bayou proper in the dredging operations.

The removal of the raft in Red River has seriously affected the interests of the city of Jefferson, in the navigation of the bayous and lakes connecting that city with Shreveport, La., and consequently with the Mississippi when there is a sufficient stage of water in Red River to reach Shreveport. These causes and effects are described in the annual reports of my predecessor in charge of the work and need not be recapitulated here. The changes still continue to take place in Red River, consequent upon the removal of the raft and the endeavors of the river to accommodate itself to the new condition imposed upon it. The river is still cutting out its banks and bed. Many plantations heretofore inundated from the back water caused by the raft formation, have been reclaimed and are now under cultivation.

It is evident that the injury to the navigation of the bayou will increase as these changes continue.

Evidently the plan was not approved by Congress, for the next appropriation, August 14, 1876, contained this item:

For continuing the work of dredging and removing obstructions to navigation in Cypress Bayou, Texas, $13,000.

This sum was withheld under instructions from the Secretary of War, September 4, 1876, until the following year, when Captain Benyaurd, under orders from the Chief of Engineers, submitted a project for continuing the work of dredging and removing obstructions. This was approved, the money expended, and $20,000 estimated for continuing work according to the same plan (1877, 488). The act of June 18, 1878, gave $15,000 for "Improving Cypress Bayou, Texas and Louisiana," which was expended in the same way. The act of March 3, 1879, gave $6,000 for the same purpose, and no more money was granted for this work for seven years. In 1879 Major Benyaurd made no estimate, but reported:

There are no more cut-offs that can be made to advantage, nor dredging to be done on the bayou, for when the steam-boats can pass Sodo Lake there is sufficient water in the channel above for all navigation purposes. In the lakes the dredge would be of no service.

It is proposed during the next low-water season to send a working party across the lakes and cut down and remove all the cypress stumps and other obstructions in the channel already selected. When this work is executed it will give good navigation to Jefferson at a time when there is sufficient water for that purpose, and will complete the project previously submitted (1879, 958).

The next appropriation was made by the act of August 5, 1886, granting $18,000 to "complete improvement," in accordance with Captain Bergland's report contained in House Document No. 103, Forty-eighth Congress, second session. His project, submitted in compliance with a provision of the act of July, 1884, for a resurvey of the route between Jefferson and Shreveport "to ascertain if the necessary improvement can not be made upon some other plan than building a dam across the Albany Flats, as recommended by the engineer," contemplated removing obstructions and dredging as carried on under previous appropriations. Congress approved this report by the appropriation above mentioned, and by the allotment of $5,000 from the appropriation for Red River in the law of August 11, 1888. (1885, 1552; 1888, 1343, and 1889, 1589 and 1595).

A re-examination of this route was made by me in 1886, with an examination of the lakes connecting with Red River between Shreveport, La., and Fulton, Ark. All of these lakes are the results of overflow from Red River during the raft period, and as the line chosen for Red River has been cleared of obstructions, the outlets from Red River through which water escaped to the westward have been filling up, while the water slope of the main river has steadily decreased.

The bottoms of the outlets are now above ordinary low water, and it is the intention of the State engineer to cut them off entirely in continuing the levee system along the west bank of the river. Whatever water supply may have been expected when Captain Howell's project was formulated (and it does not appear to have been estimated) the amount that could be obtained now is not known, the conditions having been wholly changed by the removal of the raft and continued work upon the obstructions in the river-bed above Shreveport since that time. It is known, however, that the high-water line above Shreveport has been reduced by many feet from actual observations on the levees on the east bank. The lands on that side have not been overflowed for years, and the people have ceased to concern themselves

about their levees. The depressions have not been raised to grade, and where the levees have caved into the river the gaps have not been closed. A general survey of Red River from Fulton to the Atchafalaya is now in progress to get information for the permanent improvement of the river and its tributaries, and that involves the question of probable depth that can be carried to Shreveport and beyond. Captain Howell's project for Cypress Bayou contemplated a navigable depth of only 3 feet to Jefferson as being all that would ever be required; but the people interested in Cypress Bayou will be satisfied only with a depth that will allow boats drawing at least 5 feet to run between Jefferson and New Orleans during low water. Now whatever plan shall be adopted for improving Red River involves closing outlets, and this is particularly necessary to preserve the upper river. The subject was discussed very thoroughly by Major Benyaurd in a special report sent to the chief of Engineers February 9, 1882, in response to certain communications of Judge Land to Hon. R. L. Gibson and Hon. N. C. Blanchard, from which the following extracts are taken:

The removal of the raft by the Government, however, opened up the main channel of the river, and it is now the only navigable one. Recent examinations show considerable change in the river-bed and lowering of high-water lines, with increased depths at all points measured. One important result of opening a channel through the raft is that in low stages of water very little of it is diverted from the natural channel, but flows with an even volume to Shreveport over the bed of the river proper. Another result is that the high-water line has been reduced generally within the banks, while a greater depth of water is everywhere found and an enlarged section of channel-way. Plantations that were inundated year after year before the removal of the raft have been redeemed and brought under cultivation, and are without any danger of again being subject to overflow.

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That the closing (of the outlets) would be beneficial to the interests of the *navigation of Red River* is a question beyond dispute, but I would not stop the work *above Shreveport*, but continue the same at certain points below. It must also be admitted that the work would *redeem vast quantities of land* now subject to inundation.

The closing of all the bayous at one time would to some extent be disastrous to the fertile and cultivated lands on the borders of the river below, for though at one time the river had sufficient section to carry off flood waters, the raft formation caused a filling up of the channel, and though the process of scouring out is continuing, the river has not sufficient section to carry off the flood waters entirely. If it be determined to carry out the scheme let it be done gradually, and at the same time let the river below be prepared to receive the increased amount of water it would be required to carry.

Experience has confirmed Major Benyaurd's views, and the principle now appears to be accepted on all hands. It is certainly accepted by the people interested in the navigation of Cypress Bayou, for the plan which they now desire to have investigated does not involve a water supply from Upper Red River, but consists essentially of the formation of a reservoir in the bayou proper and the lakes by constructing a dam and lock at the head of Sodo Lake and dredging a channel through the latter to Twelve-mile Bayou or to Red River. The water supply must then come from the natural drainage of the basin, and this can be determined only by a thorough survey. The amount of dredging would have to be computed, and the probable fill of the channel between the dam and Shreveport, and, finally, trial sections and borings at the sites of the proposed lock and dam. The success of this plan depends upon the following conditions:

A sufficient navigable depth in Red River to Shreveport.

The maintenance of the dredged channel between Shreveport and the dam.

A sufficient water supply from the drainage area above the dam.

Secure foundation for the dam, and a lock or locks of reasonable lift suited to the probable requirements of the trade.

The survey should be complete, both in topography and precise levels, and, as the country is a very difficult one, this would be very expensive.

The route is about 65 miles long, but as a number of section lines will be required across the lakes to determine the volume of the reservoir to be formed by the dam, the usual estimate of $120 the mile will not be sufficient. My estimate for the survey is $10,000 or $12,000, it it should be thought necessary to examine the outlets between the route and Upper Red River. The feasibility of the improvement can not be discussed until this survey is made, and the survey of Red River finished, and a plan of improvement adopted that will insure a low-water channel of at least 5 feet from Shreveport to the Mississippi. It is not possible to make estimates of the cost of a slackwater navigation between Shreveport and Jefferson, from the surveys and examinations made during the raft period.

Very respectfully, your obedient servant,

J. H. WILLARD,
Captain, Corps of Engineers.

Brig. Gen. THOMAS L. CASEY,
Chief of Engineers, U. S. A.